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A BEETHOVEN PORTRAIT BELONGING TO THE HOUSE OF BRUNSWICK.

It is most remarkable that a new portrait of Ludwig von Beethoven should have been discovered at this late day, after so many careful investigations into the life of the great master, so many jubilees on his anniversaries, and so many exhibitions of objects connected with his memory. The discovery will especially delight his admirers, because it is a very good oil painting of nearly life size, and fills a gap in the iconography. Here we have Beethoven in the prime of life, about thirty-four years old, for the picture must have been painted in 1803 or 1804. This was the time of Beethoven's life that came between a youth in which

A NEWLY DISCOVERED PORTRAIT OF BEETHOVEN

there was little joy and the development of that tragic deafness which gave its fatal warning as early as 1800—certainly the happiest period that he had known. Originality and certainty of success are stamped on this countenance, in which we find all the characteristic peculiarities which we have learned to know from the later portraits; the forehead angular, the lower part of the face projecting on account of the peculiar placing of the teeth, the ugly nose, and the hint of a dimple in his chin, which afterward became so pronounced. The picture also shows the disheveled hair, a characteristic neglect of the master and his disciples, which, however, is here counterbalanced by a certain care in the arrangement of the dress. Thus, and not otherwise, must we think of Beethoven when he appeared in the brilliant circle of Austrian nobility.

Unfortunately, the painter of this portrait, which is well preserved, with the exception of parts of the drapery, is unknown, but personal recollections, about which there has lately been much talk, are connected with the picture. Last summer, when I was making a visit at Martonvasar, the lord of the castle, Count Geza Brunswick, surprised me very much by showing me this picture, which he told me belonged originally to Beethoven himself, who gave it to the father of the count, Count Franz, who was bound to Beethoven by the closest friendship. The fact that the old count always took the picture with him when the family made the regular changes of residence between Martonvasar and Pesth, shows how highly he prized it. After knowing these particulars, one will read with increased interest the accounts of the relations between the two men given in Thayer's and other well known biographies.

For the accompanying engraving we are indebted to our worthy contemporary the *Illustrirte Zeitung*.

[From the Sun, New York.]

THE RELATION OF MACHINERY TO COMMERCIAL AND INDUSTRIAL DEPRESSION.

THE benefits derived from the use of machinery have thus far outnumbered the disadvantages, and there has been sufficient employment in most countries for the major part of the people; yet there have been serious industrial dislocations consequent upon the adoption of new processes by which the industrial and commercial interests of great populations have been revolutionized, and intense suffering brought to displaced artisans and laborers. A notable example of this is found in the effect of European machinery upon the hand loom industry of India, whereby millions of handicraftsmen were forced into the already congested ranks of agricultural labor. Thus, closing the present account, a balance may appear to the credit of machinery; but what of the future? Indeed, what of the present? And what part has machinery played in bringing about the industrial world's present unsatisfactory condition?

Under the old industrial regime, exchanges were slow and of small volume, nearly every country providing the food its people consumed, the greater part of the textiles worn, and the metals used. It was not until feudalism died and industrialism found a home in the free cities that man's inventive faculties were brought into constant use other than as an aid to the armed hand of the ruler. The decay of feudalism was coincident with the development of industrialism, with the birth of civic freedom, and with an enormous increase of mechanical aids to labor.

Estimating the power of steam, and exhibiting its beneficence, by showing the numbers of men and horses to which its applications are equivalent, has been, and still is, a favorite employment with those who ever prate of "the progress of the race and the march of improvement." Few think it worth their while to attempt to either measure the present, proximate, or ultimate effect of such tremendous forces upon individual and national welfare, and what must be the inevitable result if this "march of improvement" continues without a commensurate increase of the individual power to consume, on the part of the great mass of the populations. That mass is made up of wage earners and cultivators, and constitutes at least four-fifths, and probably nine-tenths, of the world's consumers of the products of manufacture. Nor do those optimists ever stop to inquire if such an increase of consumptive power is probable or even possible.

Fortunately for those living in the nineteenth century they came upon the stage at a time when a great part of earth's most productive areas, such as temperate North and South America, Australia, and a part of South Africa was being subdued; when new regions were affording ample scope for enterprise and homes, and employment for the immense swarms yearly leaving the European hive; when countries were being developed exceptionally productive of all the precious and useful metals, and, more important than all else, assuring, by their ability to grow a great surplus of food and fiber, the comfort of the new populations and those remaining in the ancestral lands. That is, conditions have been the most favorable possible for a great and wholly unexampled increase of agricultural, textile, and metalliferous production, and a rapid absorption of the products of manufacture by new communities lacking the capital and equipment necessary for the domestic production of the wares required. The demands of the new communities for manufactures have been supplemented by those of the inferior races who are concurrently subjected to the domination of western commerce, while the machine-made products of England, Holland, France, and Flanders displaced those of the domestic hand loom among the enormous populations of India and Asia generally.

Under conditions which have existed respecting undeveloped agricultural areas: the facility with which the emigrating myriads were able to found new homes; the creation of new markets in the younger communities; the extension of commerce among the inferior peoples; the coincident and consequent destruction of a very considerable part of the domestic industries of India and other Eastern countries; the creation of vast manufacturing, transportation, and agricultural equipments, and the ease with which an adequate supply of food and fiber has been secured by the cultivation of newly subdued areas of surpassing fertility—all these since the inventions of Watt, Whitney, Hargreaves, Arkwright, and Cartwright have made it possible to multiply the productive power of each labor unit employed in manufacture and related industries almost indefinitely, without effecting such industrial and commercial dislocations as to cause widespread suffering, except in India and lesser districts. But these conditions no longer obtaining, it becomes a very serious question how much further the progressive application of labor-saving devices can be carried without grave disturbance of both industrial and social conditions, unless there shall be a concurrent increase of individual power to consume commensurate with all increase, past and to come, of the unit power to produce. Hence the problem of the distant as well as the proximate future resolves itself into one of the possibility and probability of such an increase of the power to consume as will absorb not only all the commodities which an industrial equipment and labor force already much too great can turn out, but all that can result from further augmentation of each labor unit's productive power. This is the most serious problem that has ever confronted the human race, and is the most serious it can ever confront except the somewhat remote one of providing the food for a population that now increases four times as fast as does the food-bearing area.

This problem involves an inquiry as to the measure in which the unit power of production has increased this century.

Adam Smith died without a knowledge of the condensing steam engine, the cotton gin, or the electric telegraph. He had never seen a railway, steamship, or grain harvester, and knew, probably, little of the spinning jenny, power loom, or of one per cent. of the many thousands of labor-saving devices brought into use during the last one hundred years, that have certainly multiplied the unit power of production, in the sum of all manufactures, not less than fiftyfold and probably more than one hundredfold.

In cotton spinning, one man and two boys now produce as much yarn as did 1,100 spinners using the single-spindle hand wheel; and one operative employed in weaving turns out forty to fifty times as much cloth as did the hand loom weaver. It is manifest that there can never be an equivalent increase of the unit power to consume cotton goods.

In the case of woolen and other superior textiles, the increase of unit productive power has been less; yet, it has been far in excess of any possible increase of the unit power to consume. Moreover, in most textile manufactures the robust hand loom weaver has given place to the female and child, and this sends the male descendants of the hand loom operative to the recruiting office in increasing numbers.

Formerly lace making was a household industry of great importance in western and central Europe, but machine-made lace has displaced the greater part of the hand made; and while it is impossible closely to approximate the amount of labor thus displaced, it is very great, as has been the distress thereby brought to villager and peasant, whose meager incomes have been cut in twain, with much of their purchasing power destroyed. Lace is a luxury, and while cheapened production has extended its use, this extension bears but a slight proportion to the labor displaced.

Swiss watchmakers were able to turn out an average of forty watches a year. Each operative in an American factory turns out from 250 to 300 watches yearly, machinery displacing fully eighty per cent. of the labor. While the lessened cost of watches has greatly extended their use, such extension is far from being commensurate with the increase of each labor unit's productive power. When the whole population shall be fairly well supplied with an article so durable, and the cost of food shall absorb an increasing proportion of diminishing individual revenues, the power to consume watches will decline, and the displacement of labor will be severely felt in such communities as that of Switzerland. Even now, the power to produce is so excessive that prices are maintained only by combinations to restrict the number of watches made. With the multiple forms of woodworking machinery, the labor of one man now equals that of one hundred in the days of Adam Smith, except in the finest cabinet and carriage work. Similar reductions have been made in the labor involved in the production of articles made of both wood and metal, and in all such forms the lessened cost of production increases consumption in only small degree.

In the paper-making and leather industries the labor displaced by improved processes averages quite ninety-five per cent.

The amount of labor displaced by machinery in the boot and shoe trade is a fairly well kept trade secret, but the proportion is very great, although the retail price of the product falls but slowly; and the increase of unit consumption is so slight as to afford no compensation for the increase of the unit power of production. In the very nature of the case, there can be no great increase of the unit power to consume.

Telephones are machines which have displaced labor by the elimination of the messenger, but they enable no one to consume the product of labor except as a result of their construction and maintenance. This is a mere trifle.

On the other hand, while the telegraph may be called a machine, it appears to have added to, rather than diminished employment. This cannot be said of the general applications of electricity, which are daily displacing more and more labor, a notable example being the device for stamping letters automatically.

Railways have displaced the stage coach, the canal boat, the carter, and lake and river craft of every description; still it is questionable if their construction and equipment have not, till this time, added to the sum of employment; but for the most of the civilized peoples the work of railway construction and equipment has largely been accomplished, and yet they may be looked upon as wholly beneficent, as aiding the laborer by increasing his mobility and distributing his products, which otherwise, in some cases, would decay at the place of production. In fact, railways and telegraphs differ radically from productive machinery, although they so greatly facilitate production by speedy communication and transport and by bringing material with regularity to the place of conversion. Yet the sum of labor now employed in transporting by rail a given quantity of commodities is not more than half—if more than one-third—of what it was thirty years since, and the power of the labor unit to transport increases yearly.

A most notable instance of the increase of unit productive power is found in the latest forms of the printing press, which turn out hundreds and probably thousands of times as many square feet of printed matter for each pressman employed as did the hand press of Franklin's day. The type-setting machine is sending the compositor to the rear with great celerity, as other machines are sending to the rear the makers of the cheaper books, while diminishing the labor required on the higher priced. Unlike wheat, shoes, and such indispensables, the lessened cost of printed matter increases the unit power to consume, but even here such increase is relatively small as compared with an enormous increase of the unit power to produce.

It is impossible to even approximate the increase of unit power of production in such employments as quarrying, mining, and the carriage of sea-borne commerce, by reason of the application of labor-saving devices and the substitution of large steam craft for the smaller sailing vessels. The steam engine, electric lighting of mines, the diamond drill, compressed air, coal and rock cutting machines, and an innumerable array of other devices have lessened in an extraordinary degree the labor force required to accomplish a given end: just as the enlargement of the water craft and the railway vehicle and the substitution of steam for sails have increased immensely the unit power to move commodities and people by land, lake, river, and ocean. This displacement of labor, increasing now at a progressive rate, has been accompanied by not the least increase of the unit power of the labor employed to consume the products of other labor, except in the measure of the reduction in the price of such products.

In the conversion of ore and metals into useful forms, machinery and labor-saving processes have effected nearly as great an increase of the labor unit's productive power as in the case of textiles, although the ratio of increase varies with every product. Still, each workman now employed in such industries has quite as great an average productive power as had 100 in the days of Adam Smith.

For each operative employed, the Burden horseshoe machine turns out as many shoes as 500 blacksmiths can make with anvil and hammer; and a single nail-making machine turns out for each labor unit employed, more nails than 1,000 men could shape by hand.

Although in agriculture the displacement of labor by machinery has been relatively much less than in other forms of production, even in the United States, Canada, Australasia, and Great Britain, where alone it has come into general use, yet so great has been its effect that Mulhall estimates the productive power of one unit of American agricultural labor as equal to that of nine in Europe. If the small size of most European holdings did not preclude the use of machinery, there can be no doubt that the displacement of agricultural labor upon the Continent would be nearly as great as in the United States. In America, notably in the Northern and Western States, the use of farm machinery has been stimulated by scarcity of labor in recent periods, and by the size of farms. Large farms render profitable the use of appliances that the occupier of the small holding can afford neither to buy nor to operate; and this, again, has a very pronounced tendency to increase the size of farms.

Probably the use of labor-saving devices and the cessation in large part of forest removal, have, since 1850, quintupled the productive power of each labor unit employed upon American farms; but it is certain that this increase of the unit power to produce has, so far as the whole food-consuming populations of the temperate zones are concerned, been offset by but slight increase of the unit's power to consume farm products; and the excessive production of food by reason of the cultivation of too many acres, facilitated and made possible in some degree by machinery, has greatly reduced the power of the labor units employed on the farms in the United States, as elsewhere, to buy of the products of the fabricants' labor. So far as food staples are concerned, machinery, from the very nature of things, exerts a most disastrous effect upon the agricultural wage worker by lessening his employment without the possibility of compensation for the community by increase of unit consumption of farm products. Machinery has driven the farm laborer out of the field and to the crowded railway, mine, and factory, where he competes with others for employment rapidly growing relatively less.

Had it been possible to reduce to the American ratio the labor required to cultivate a given number of acres in Europe, India, China, and Japan, and had the displaced workers been forced into the ranks of those fabricating and distributing wares, as they necessarily must have been, what a frightful condition would now be that of the wage earners of all lands! Yet this would have been but a further exhibition of "the progress of the race and the march of improvement." When we contemplate the possibility of such conditions, we can heartily commend the wisdom of the Chinese ruler who, legend hath it, caused all the farm machinery in the empire to be destroyed and its reconstruction prohibited upon pain of death, because it robbed the people of the employment necessary to their very existence.

Were it possible to substitute machinery for hand labor in India, in the same ratio to cultivated acres as in the United States, nearly or quite half of a population of 300,000,000 would thereby be deprived of the work and earnings absolutely necessary to their existence, as there is no other possible employment.

The industrial equipment of the western nations is quite sufficient to supply the whole world's population with much more of nearly every product of manufacture than can possibly be consumed. There are great and rapidly increasing additions to the industrial equipment of India, China, Japan, and even of such countries as Afghanistan, by the adoption of western processes and the best machinery of European make. The cultivator's power to purchase has been greatly diminished, the world over, by reason of excessive additions to the cultivated acreage, made mostly in the United States since 1870. The revenues and expenditures of artisan and laborer everywhere are steadily decreasing because of lack of work, due to the inability

of cultivators to buy as largely as formerly of the product of others, and by reason of the enormously increased power of each industrial unit to produce. Vast masses of labor are partially idle, and retain but little purchasing power, which have heretofore been engaged in the construction of steamships, railways, and existing industrial equipments. All this being so, it would be wholly unaccountable had not activity and prosperity given place to stagnation, vanishing profits, lower wages, idleness, and distress, as well as to a constantly diminishing ability to consume wares for the production of which the available labor is as excessive as the equipment.

Excessive power to fabricate has destroyed much of the power to consume the products of manufacture; and the low price of food and fiber, due only to an excess of cultivated acres and the resulting excess of agricultural production, intensifies this inability to consume, by diminishing the landowner's and the cultivator's power to command the products of others.

In short the commercial and industrial world suffers from such an excess of all forms of productive power as greatly to lessen the consuming power of any given population for everything except indispensable articles of food. And this is wholly due to an increase of the unit power to produce fabrics; that is machinery alone has produced this condition.

Only in the direction of soil production is there any great and, at the same time, lasting improvement probable or even possible; and here only because of man's inability to multiply, with all the aids at his command, the acres which are actually or potentially productive, and which are now so nearly occupied as to not much longer make it possible to grow a plethora of grain, meat, and cotton.

On the other hand, the products of manufacture are easily capable of infini e multiplication, as, given the food, is man. And their production in excess of the power to consume is assured by existing conditions which indicate an indefinite if not an unending period of falling wages: lower prices for all products, other than those of the soil, where not maintained by combinations to restrict production; a ratio of profits declining as do prices, and a general if gradual lowering of the standard of living.

Aside from the passing effects of an acreage long excessive, but now little if any in excess of current needs, these results, deplorable as they are, follow inevitably from the enormous increase of each labor unit's power to produce. Such increase is directly traceable to the adoption of labor-saving devices that were but mere possibilities in the days of Adam Smith.

THE MAGIC TAMBOURINE.

THE prestidigitator, taking a tambourine formed of a sheet of white paper and two silver hoops, bursts the paper with his fist, and pulls out two silk handkerchiefs and a lot of serpentines. Then, gathering up the paper, he causes a turtle dove to appear.

This trick is performed as follows. Take a circle of telegraph tape (Fig. 1), place upon it two small silk handkerchiefs folded square, and cover the whole with a disk of white paper of a little wider diameter than that of the ring of tape. Turn down the edges of the paper (Fig. 2), fasten them with paste to the sides of the tape, and place the whole in the inside of your vest, to the left, the white paper against the shirt. In the other side of the vest place a turtle dove.

Having manufactured your tambourine, hold it against your breast, and, with the thumb and forefinger of your right hand hidden by it, seize the roll of tape and introduce it into the interior of the tambourine in making the whole slide from left to right.

Now burst the head of the tambourine, take out the two handkerchiefs (Fig. 4), and pull upon the telegraph tape, and unwind it up to the very end (Fig. 5). Then lay down the tambourine and allow the paper to fall.

Stooping over, gather up the paper in a bunch (Fig. 6), in front of your breast, and profit by this moment to grasp the turtle dove with the left hand and introduce it into the interior. Lay the whole upon a stand, and, separating the strips of paper, take out the dove (Fig. 7).—*Le Magasin Pittoresque.*

Fig. 1. Fig. 2. Fig. 3. Fig. 4.

Fig. 5. Fig. 6. Fig. 7.

THE MAGIC TAMBOURINE.

SLEDGE RACING IN HOLLAND.

OF the numerous forms of ice sport in Holland, none are more interesting than the races in pricking-sledges. These take place principally in out-of-the-way districts, where the peasants still dress in their national costumes. As a rule there is not much color in Dutch native dresses, but those worn in some parts of Friesland are more picturesque than in other places, and especially is this the case at the old town of Hindeloup. On the occasion of a skating meeting the inhabitants for miles round flock into the town, and the greatest excitement prevails. There are all sorts of contests, skating for both men and women, sledging of the ordinary kind, trotting for horses, and then races in these pricking-sledges. They are made of wood, often beautifully carved or gayly painted, and the competitors sit in them and propel themselves along with short sticks with iron points, so as to get a firm grip of the ice. The courses are of only a short length, but the interest caused is very great, and as it requires a considerable amount of skill to steer the sledge in a direct line, collisions are frequent, and much hilarity caused by them and the erratic movements of some of the competitors. The proceedings are altogether of a most unique character, and no visitor to Holland in the winter should fail to attend such a meeting, if it is at all possible to do so.—*The Graphic, London.*

A SLEDGE RACE AT HINDELOUP, IN HOLLAND.

JAPANESE HOT SPRINGS.

BEING out on the coast of Corea and Japan, looking for things curious, I secured from the natives intelligence of a remarkable place in the remote interior of an island belonging to Japan called Kiushu. The place is commonly called "Seven Hells," and, on account of its inaccessibility and remoteness, has seldom been visited by Americans or so much as referred to in print. I determined to visit this Japanese inferno, and having everything arranged I set out with provisions for a two weeks' travel. The first few days were spent in a small Japanese steamer crossing three or four inland seas, and winding around at least a thousand different islands to get in reach of the mainland that would lead me to the end of my journey. It may appear to be an exaggeration to speak of so many islands and seas, but when it is remembered that Japan alone has 4,000 islands and at least 100 different seas, it will not appear strange that I passed 1,000 islands in search of the one on which is the phenomenon.

When I had got as far as I could go by water, there was nothing left for me but to try the crude mode of travel of the islanders for 100 miles or more. I hired a jinriksha and two coolies to pull me, and at once proceeded. A whole day and night were spent in this funny vehicle, until I came at last to mountains so steep that it was impossible for me to ride further. Then another change in my mode of travel was made. I hired a coolie and pack horse to carry my baggage, while "I took my foot in my hand and walked" for twenty miles over that rugged mountain.

Once over the mountains I was almost in sight of the "Seven Hells." An arm of another sea lashed up in a narrow neck. On every side stood gigantic mountains capped with snow, while below lay the beautiful valley. It seemed as if I might be entering Paradise. I walked a little further, and in a moment the earth resounded as if a thousand cannons were exploded beneath me. I had reached the "Seven Hells," and all that had been told me of the place was fully demonstrated.

Just a few yards from where I stood was the "Boiling Sea." A great smoke and steam arose like a cloud from the water, and upon examination I found that the sea of water was boiling and bubbling like a pot over a stove. The water was scalding hot, and would cook an egg in two minutes. This boiling sea is considered sacred by the natives, and the government had at one time to erect a fence around it to keep the people from plunging in.

From the Boiling Sea a continual stream of hot water runs down through a village of about 300 people, who are the most peculiar human beings outside of China. In the center of the village is a big round bath of hot water from the sea. In this bath from ten to twenty-five are constantly to be seen bathing. There are no screens or coverings, but men, women, and children all bathe together in Adamic simplicity. I saw at one time nine women and ten men in the bath.

About fifty steps away from this place is a "sweat bath," dedicated to one of their gods. An open shelter is built in the streets over a cavern in the earth which they say Buddha built for them. The excavation has a door to it similar to an old-fashioned sweet potato house that Southerners build to keep their potatoes from freezing in the winter. The door is about three feet square, and there is no way for either a person or the steam to escape except by this door. In the front were priests selling tickets for half a cent each, and six persons were admitted to the sweat bath at once. Just over the entrance stands an image of Buddha, with rice cakes, flowers, and incense offerings. The people worshiped as they went in, while an old priest stood by telling the people that whosoever bathed in faith should be cured of all maladies. The lame and crippled flocked around and listened with eagerness. The priest said that Buddha sent down his angel, who met an ancient priest and told him that he would write the name of Buddha on a stone and cover it with the earth and cause the mountains to gush out with hot water and flow over the name of Buddha for the healing of all diseased believers. "This," said the priest "is the place prepared by the great gods, and if you would be

healed enter in and bathe." It was amazing to notice the deluded men and women, in companies of six, go into the bath and stay until almost dead from suffocation, and come out dripping with perspiration and covered with straw. It seems that a stream from the Boiling Sea runs under the excavation, and inside is thrown a lot of straw on which these men and women spread themselves and stay until they fairly roast themselves alive. From this place they go to a hot shower bath, which consists of several large bamboo poles placed in a waterfall from the hot sea, which fell about ten feet upon the bodies of the saints just from the sweat bath. From the shower bath they go to the fountain bath, where the course is completed. The entire process often takes several hours and is gone through without clothing or towels of any kind. This keeps the streets alive with men and women walking here and there as naked as they were born into the world.

Another peculiarity of this strange people is the way they cook and eat. Everything they do has some religious superstition connected with it, and their cooking and eating are not an exception. I am safe in saying that no people on earth cook like the people who live at the "Seven Hells" on the island of Kieushu, in the marvelous little nation of Japan. They have arranged to run the water from the Boiling Sea in small streams, about a foot under the surface of the earth, right in front of every man's door. Over these streams are mud ovens built like a pot, with a lid over some of them. In their ovens the people place whatever they want to cook, and the steam from the hot water does the work. This is certainly better than natural gas. Many of the people, and in fact most of them, merely dig a hole down to the hot steam, place some straw over the water, and put their potatoes, etc., in and cover them up for a while until they are ready to eat. I saw many people cooking in this way.

REFRIGERATING APPARATUS.*

By Prof. CARL LINDE, of Munich.

THE results of recent investigations on low temperatures have never before been brought under public notice in so complete and comprehensible a manner as has been done by Professor Dewar in his lectures on the liquefaction of gases, investigations commenced by Faraday and continued by a number of physicists, but in no case with greater success than by Professor Dewar.

I will select from those lectures only the description of a method by which it is possible to liquefy the substances called up to recent times permanent gases, especially the constituent parts of atmospheric air (oxygen and nitrogen). If we take a drum filled with liquid carbonic acid (as obtainable in commerce) and allow the carbonic acid to pass into a vessel (Fig. 1) in

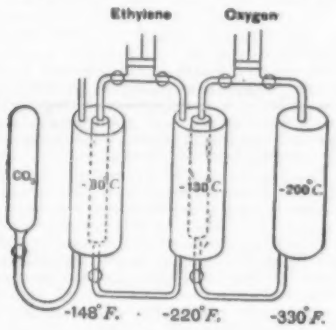


FIG. 1.

which atmospheric pressure is maintained, the carbonic acid will boil at —80° C. (—112° F.) If we now compress ethylene vapors by means of a compression pump into a second vessel placed inside the first receptacle, it will liquefy, and, on allowing the liquid ethylene to enter a third vessel, inside which atmospheric pressure is maintained, the boiling point of the liquid will be about —100° C. (—141° F.) If, however, the pressure were to be reduced, then the boiling point of the liquid could be lowered to —140° C. (—220° F.) If, further, by means of a second compressing pump, oxygen be compressed into a closed vessel placed within the ethylene vessel, liquid oxygen is obtained, boiling under atmospheric pressure at — 180° C. (—290° F.), and by reducing this pressure the last named temperature can be lowered to —200° C. (—328° F.), at which point atmospheric air will condense on the surfaces of the vessel, even when not compressed.

Here, then, is a way opened for technical enterprise, enabling us, by methods now fully available, to produce and maintain temperatures below —200° C. (—328° F.), and not far distant from absolute zero, which we know physical science to place at —273° C.

The uses to which industry may put this discovery cannot as yet be certainly defined. The lowest temperature hitherto employed for industrial purposes is —110° C. (—166° F.), a temperature utilized to distill in vacuo the subtilest constituents of certain organic substances, and to produce them in this manner of a purity hitherto unknown.

Excepting these isolated applications, the temperatures, for the creation of which the industry of to-day employs refrigerating machines, do not lie greatly below the freezing point of water, and in at least 95 per cent. of all applied cases, there is a demand only for temperatures above zero Fahrenheit. But inside this narrow temperature range, refrigerating machinery has found within the last two decades an application so extensive and manifold that it would take an entire evening to enumerate and describe them briefly. Probably no other branch of mechanical industry, with the exception of electricity, has developed so rapidly during that time. Our industries may avail themselves of a number of machines and apparatus which are capable of creating and maintaining in an entirely reliable manner the desired temperatures. Those who require refrigeration need not to-day consider the question of the machine system supplying the cold in a reliable and regular manner, but they will seek to find the machine which will accomplish this in the most economical way; that is to say, the machine which will produce a given amount of cold with the least expenditure of work (or fuel) and of water.

I now propose to make a comparative review of the methods and the economical value of the working processes as they are performed by machines and apparatus chiefly in use at the present day.

The first attempts to construct such machines and apparatus were made with reference to certain isolated physical phenomena, and efforts were directed toward the utilization of these without any explanation being available as to the relation between the production of cold and the requisite expenditure of heat or mechanical work. It was only subsequent to the development of the mechanical theory of heat, and the application of its laws to the contemplation of the caloric processes in such machines, that inquiries could be made with success as to this connection between production and consumption. The following questions could then be put:

1. What efficiency (relation between production and consumption) is really obtainable?

2. What is the working process permitting the attainment of such results?

3. What position do the existing refrigerating machines hold with regard to the foregoing points?

Here we have to start with the consideration that the production of cold is a process by means of which heat is abstracted at a temperature below that of our surroundings, and, seeing that its annihilation is impossible, according to the principle of the conservation of energy, raised to such a temperature level that it can be transferred to surrounding parts (for instance, to the atmosphere or to water, briefly termed further on, "cooling water"). We may compare such a process to the action of a pumping engine having to keep the water in a shaft at a certain level by raising all inflowing water to a height from which it may flow away. (Fig. 2.)

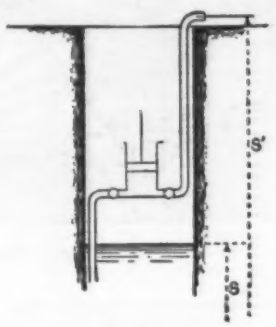


FIG. 2.

The raising of heat from a lower to a higher temperature (and it is herein that the action of a refrigerating machine consists) can, like the lifting of water, be effected only by the expenditure of a certain quantity of mechanical work. Concerning the amount of this work, we are taught by thermo-dynamics as follows:

If T be the temperature at which the heat is to be abstracted, and its quantity, H, heat units, and if T' be the temperature at which the heat can be transferred to the cooling water, then there will, for this purpose, be required a quantity of work, W, determined by the first law of thermo-dynamics by the relation—

$$A\,W = H' - H \quad \ldots\ldots (1)$$

Herein A denotes the thermal equivalent of work and H' the heat discharged at the temperature, T'. The foregoing relation expresses, therefore, that the discharged heat, H', is equal to the abstracted heat, H, plus the equivalent of the mechanical work expended, seeing that this latter, imparted from outside, cannot disappear, but must be transformed into another form of energy, *i. e.*, in this instance, heat.

Assuming that the heat, H, be abstracted exclusively at the absolute temperature, T, and that H' be rejected exclusively at the absolute temperature, T', the second thermo-dynamic law expresses that the heat quantities, H and H', are proportional to the temperatures, T and T', thus:

$$\frac{H}{T} = \frac{H'}{T'} \quad \ldots\ldots (2)$$

or by inserting the value of H' into the relation (1)—

$$A\,W = \frac{H}{T}(T' - T) \quad \ldots\ldots (3)$$

The last formula expresses that, for the purpose of abstracting the quantity of heat, H, at T degrees (or in order to produce H heat units of cold) and raising it to the level, T', a certain number of work units, W, are requisite, if working with a perfect engine without any losses whatever.

I now explain this connection graphically. If in

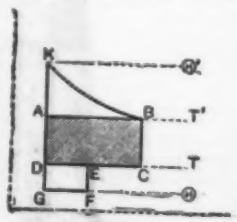


FIG. 3.

Fig. 3 the absolute temperatures are plotted as ordinates, and the values of $\frac{H}{T}$ and $\frac{H'}{T'}$ as abscissæ, then the equivalent of the work will be represented by the rectangle, A B C D, the length of which is $\frac{H}{T} = \frac{H'}{T'}$, and the height T' — T. For a given temperature, T, the minimum work corresponding to the production of a certain quantity of cold, H, is directly proportional to the difference of temperature, T' — T.

After just having compared the process of producing cold with lifting a weight of water, we now find a complete analogy to exist for the relation of the terms expressed by work. Referring to Fig. 2, we find the theoretical work for pumping to be:

$$W = G\,(S' - S),$$

G denoting the weight of water lifted. We recognize a complete identity, if G be put equal to $\frac{H}{T'}$, and in consequence of this analogy the term $\frac{H}{T}$ (designated in physical science as "entrophy") has been called "heat weight." In passing, I may point out that seemingly a difference does exist, because the heat weight $\frac{H}{T}$ of a certain heat quantity varies with the temperature, T, while G is considered as a constant value. But if we consider that $G = m \times g$, and that g (the acceleration by gravity) increases as the mass, m, approaches its center of attraction, that, consequently, also G is really variable, and that we are accustomed to consider G as constant only because the values of S' — S, with which we have to do, are relatively very small, as compared with the distance to the center of attraction, that, consequently, also G is really variable, and that we are accustomed to consider G as constant only because the values of S'—S, with which we have to do, are relatively very small, as compared with the distance to the center of attraction, then we find, indeed, a complete analogy, provided we place the absolute zero and the center of attraction side by side. In our caloric processes, however, the difference, T' — T, is by no means infinitely small in comparison with T, and thus the latter must be taken into account.

By keeping in view the analogy between the performances of our caloric engines and those lifting weights, it is possible to demonstrate the working process of each single machine in a simple and intelligible manner, and to obtain a correct representation of the nature and value of these processes, even without mathematical deductions, which render to many the study of thermo-dynamic problems a matter of difficulty.

The consideration of the working process of the most important existing refrigerating machines has been selected by me as the special subject of my present paper. Let us consider again more closely the equation—

$$A\,W = \frac{H}{T}(T' - T).$$

It holds good, on the assumption that the abstraction of the entire heat quantity, H, be performed exclusively at the temperature, T, and that the corresponding heat quantity, H', be rejected exclusively at the temperature, T'. In the event of part of the heat being abstracted, not at T, but at a temperature higher or lower; if, for instance, only the part, E C (Fig. 3), of the heat weight be abstracted at T, while the heat weight, F G, be abstracted at 0, then the work to be expended would be represented by the area, A B C E G F; or if the rejection of heat took place, not at the constant temperature, T', but a rising temperature corresponding to the line, B K, then the increase of work to be expended will be indicated by the area, B K A.

We perceive that a consideration of the formula $A\,W = \frac{H}{T}(T' - T)$ permits of an immediate answer being given to the questions raised.

1. It conveys to us the amount of theoretical work requisite for the abstraction of a certain amount of heat at a given low temperature, T, and for its rejection at a given higher temperature, T'; in other words, how many thermal units of cold at certain conditions of temperature can be produced per working unit, or, say, per horse power.

2. It teaches us that the working process enabling us to attain this most favorable efficiency must be conducted in such a manner that at no single point heat is abstracted at lower temperatures than those strictly determined by the given problem, and that the heat must not be lifted any higher than is absolutely necessary for its rejection to the cooling water. A process satisfying these demands is termed a perfect process.

I now, on the basis of the preceding data, pass on to the investigation of the third question: How do the existing refrigerating machines correspond to the results theoretically obtainable?

The classification of refrigerating machines into three groups is well known, namely, those in which the refrigeration is based upon the *expansion of atmospheric air;* and those basing the production of cold upon the evaporation of a volatile liquid, the return to liquid state being effected either by *compression* or *absorption*.

Fig. 4 represents the cold air machine as usually now employed, and we will assume that the freezing chamber, R, has to be maintained at the temperature, T. The compressor draws in air (wholly or partly out of the chamber, R) and compresses it to about three or four atmospheres, the work of compression being simultaneously converted into heat and the air being heated to the temperature, 0'. By means of direct or indirect contact with cooling water, this air is reduced, as near as possible, to the temperature, T', of the cooling water, and is then admitted into an expansion cylinder, there expanding to atmospheric pressure: hereby the equivalent of the work expended upon the expansion piston is abstracted from the air and its temperature is accordingly lowered to a certain temperature, 0. The air enters the freezing chamber, R, at

* A lecture delivered before the Society of Arts, London, March 7, 1894. —*From the Journal.*

this latter temperature, and abstracts heat from the air in this chamber by being heated from θ to T.

How far does this performance correspond to the conditions of the perfect process? The problem set to the machine amounts simply to maintain the room, R, at the temperature, T, *i. e.*, to abstract all heat developed

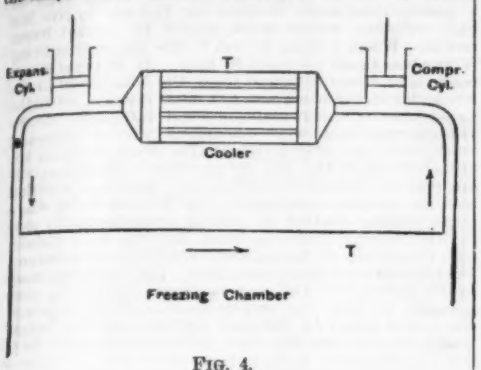


FIG. 4.

in this chamber or entering it from without, at the temperature, T. This is here accomplished by introducing the air at a far lower temperature, θ, and heating it to T. We recognize at once that the work, A B C D (Fig. 5), theoretically necessary for lifting the heat weight has been increased by the area, C D E, because the heat weight must be lifted, not from the constant level, T, but from a depth varying between θ and T. But let us continue. The compressor aspirates air of the temperature, T, and compresses the same with a simultaneous rise of its temperature. If the compression takes place, as it is in principle, adiabatically—that is to say, without the addition or abstraction of heat—then the rise in temperature must, at least, be equal to T—θ, because, according to formula 1, there must be rejected between θ' and T' the same quantity

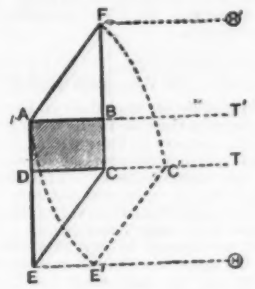


FIG. 5.

of heat which has been abstracted between θ to T, plus the equivalent of the expended mechanical work. Thus we find present, also, in an upward direction, an excess of the theoretically requisite work determined by the area, A B F. The circumstances are the same as if we had to lift a weight from a height, T, to a height, T', and effected this in such a manner that we allow the pit cage to descend to θ, then fill the load into it while raising it from θ to T, and as it the cage were then lifted to θ', and afterward let down to T', discharging the load during the last movement. We have not here to deal with small heights, for, unless the cylinder dimensions, and with them the external losses, are allowed to attain gigantic proportions, the temperature, θ, of the air admitted into the chamber at E must be far below that of the air temperature, T, in R. If we put the latter at 20° F. and assume the incoming air to be at 75° F., then each cubic foot of air will abstract about two thermal units, while at the same tem perature the formation of one cubic foot of ammonia vapor would abstract about 83 heat units. If the cooling water temperature be 65° F., and if in consequence the temperature lift required from the machine be 45° F., then E D will be twice as great as A D, and we observe that in this instance the area, A F C E, is about three times larger than the minimum of work theoretically required (A B C D). In addition we must consider that the reduction of temperature during expansion—in consequence of various losses (especially through exchange of heat through the cylinder walls, through leakages, through the presence of water, etc.)—is far smaller than it should be according to the pressures. This produces the same result as if the expansion were performed, not adiabatically, but under a simultaneous imparting of heat to air, expanding from A to E', and consequently the requisite work becomes actually much greater, as represented by the area, A F C' E'. If we add the further increase of work due to the exterior resistance of the relatively very large working cylinders, it will be clear why the best executed cold air machines possess an expenditure of work surpassing at least tenfold the minimum consumption of power found from the relation—

$$A\,W = \frac{H}{T}(T'-T)$$

Leaving the cold air machines, I now turn to the second class of refrigerators, working on the principle of evaporation and compression of a volatile liquid.

The annexed figure (Fig. 6) represents the working principle of such a machine; they have been termed "cold steam engines" by Zeuner, as they represent simply the reversal of a steam engine. The liquid (sulphurous dioxide, ammonia, carbonic acid, etc.) enters the coils of the refrigerator, evaporates in them, and thereby abstracts the heat necessary for evaporation (latent heat) from the surrounding liquid (brine, for instance), at the temperature, T.

The vapors thus generated are aspirated by the compressor and forced into the condenser at a pressure corresponding to the temperature, T', at which the transfer of the latent heat to the cooling water is rendered possible. The condensed liquid returns by the regulating valve into the refrigerator. Let us now ask to what extent does this process satisfy the conditions which we have found to constitute the perfect process.

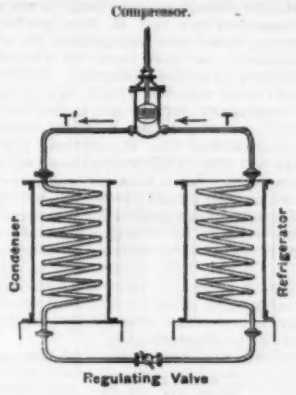


FIG. 6.

The abstraction of heat is performed in the refrigerator at the temperature, T (Fig. 7). The compressor then lifts the heat without any addition or removal of heat (*i. e.*, adiabatically) to the temperature level, T', whereupon it is transferred to the cooling water at this latter temperature. Thus far the process corresponds to the conditions specified. As regards the return to the lower temperature, T, this should be performed without addition or rejection of heat (*i. e.*, under adiabatic expansion), but as the liquid streams under the influence of the pressure p' through the regulating valve into the refrigerator standing under the pressure, p, its liquid heat is reduced from q' H U to q H U and this heat $(q'-q)$ abstracted at decreasing temperature (A E) is employed to evaporate part of the liquid before its entrance into the refrigerator. There will be thus imparted to the refrigerator the liquid heat,

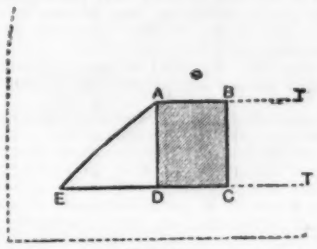


FIG. 7.

$q'-q$, at the temperature, T, corresponding to the refrigerator pressure, p (E D).

I am neglecting here, as being comparatively small, the equivalent for the work corresponding to the transit of the liquid from the pressure, p', to that of p, which strictly should be added. Hence we have, as a fact, that the weight unit of volatile liquid flowing from the condenser to the refrigerator enters the latter as a mixture of liquid and vapor, the vapor part being

$\frac{q'-q}{r}$, if r denotes the latent heat of the weight unit at the temperature, T.

The greater, therefore, $q'-q$ as compared with r, the greater will be that portion of the aspirated and compressed vapors which arrives at the refrigerator already in the state of vapor, and the smaller will become that part of the aspirated vapors which has been formed in the refrigerator, and has abstracted heat from the surrounding brine. Only the removal of the last named heat can be regarded as useful refrigeration, but the work of compression has to be performed not only upon the vapors usefully developed in the refrigerator, but also upon the vapors represented by

$\frac{q'-q}{r}$, the formation of which does not contribute to useful refrigeration. Consequently the total requisite work of compression is increased closely in proportion to the ratio, $\frac{q'-q}{r}$

While for the perfect process the nature of the volatile liquid is entirely immaterial, we find for the process, as actually carried out, the efficiency to be dependent upon the ratio between liquid heat and latent heat, and in this respect the various liquids in use behave very differently. I should now like to deal with this more fully.

If we intend to transform any liquid possessing the temperature zero into saturated vapor of the temperature, t, we have to convey to the weight unit of liquid an amount of heat termed "total heat," and composed first of the liquid heat, q, that is, the heat necessary to raise the temperature of the weight unit from zero to $t°$, and, secondly, of the latent heat, r, that is, the heat necessary to convert the weight unit of liquid of the temperature, t, into saturated vapor of the temperature, t, under the pressure corresponding to this temperature. If we plot in a diagram (Fig. 8) the temperatures as ordinates, and as abscissæ, both the liquid heats (q) and the total heats ($\lambda = q+r$), we obtain curves leaning away continuously from the ordinate line in their upward course, because both heats increase with increasing temperatures.

The accompanying figure represents these values for the two most important volatile liquids, ammonia and carbonic acid; and we recognize at first sight that for ammonia the values of r are relatively far greater to those of q than for carbonic acid. We even notice the fact that for a certain temperature, r is reduced to nought, such temperatures constituting the so-called "critical temperature."

The following considerations will show that such must be the case: If in a diagram the temperatures be plotted as ordinates, and the specific volumes (the volumes of the weight unit) of the liquid and of the

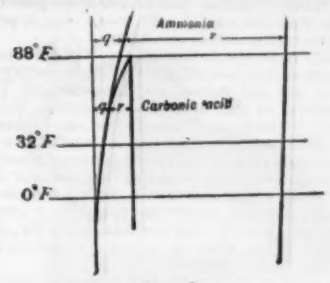


FIG. 8.

saturated vapor as abscissæ; $a\ b$ will represent the curve relating to the liquid (the volumes of the liquid *increase* with the temperature); and $c\ b$ will denote that for the saturated vapors (the specific volumes of these *decrease* with increasing temperature). Thus there must exist a temperature at which the volumes of the liquid and of the saturated vapors coincide, *i. e.*, at which no change of volume is involved for the transition from the liquid state to that of saturated vapor, and at which, consequently, the requisite demand for latent heat is nought.

It follows that the refrigerating efficiency of a cooling machine, in which the volatile liquid is conducted to the regulating valve at the critical temperature, is reduced to nothing, as long as saturated vapors only are withdrawn, because in this case the liquid heat, $q'-q$, equals the latent heat, r. But if the vapors are brought to the refrigerator with a temperature of θ (Fig. 9) lying far below that of the brine, T, then they

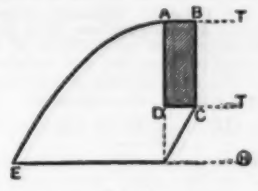


FIG. 9.

may be enabled, by assuming the superheated state, to abstract from the brine a certain (specific) heat, and to maintain some amount of refrigeration. Fig. 8 represents the work theoretically required by the area, A B C D, while the area, A B C E F, expresses approximately the actual expenditure of cost, if all losses from other sources be neglected.

It will be clearly recognized from what has been said that it is disadvantageous to employ in a compression machine a volatile liquid possessing its critical point within or close to the temperature range within which the working process is performed, because in such a case the liquid heat, $q'-q$, is relatively great in comparison to r. If, on the contrary, a volatile liquid be selected, for which the ratio between these two heat quantities is small, for instance ammonia, then the process, as performed in a compression machine, approaches the theoretically perfect performance so nearly that, according to incontestable proof, up to two-thirds of the cold determined by the relation $\frac{H}{A\,W} = \frac{T}{T'-T}$ can actually be obtained under ordinary conditions of working.

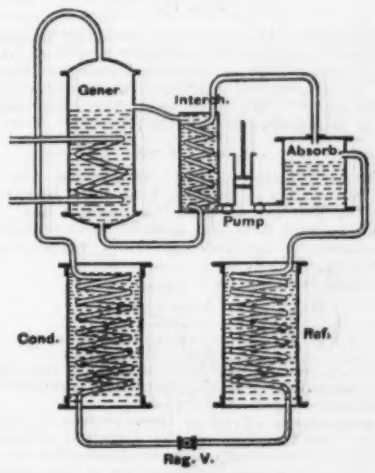


FIG. 10.

The third group of refrigerating machines—absorption machines—have a condenser, a regulating valve, and a refrigerator, just as in the case of the compression machines; but the compressor is substituted by a combination of other elements, whose functions, I believe, are well known. The ammonia vapors are, in the first place, absorbed by a weak solution of ammonia in water, which, after having been saturated, is pumped into the generator, exchanging on its way its temperature with that of the weak solution coming from the generator. The temperature in the generator is then raised by means of heating (mostly done by steam) to such a degree that the ammonia is driven out from its solution, and that the corresponding pressure of the developed vapors is sufficient to force them into the condenser, where they are liquefied at the temperature, T'.

The working process is, therefore, identical with that of the compression machine in the following

points: At the constant temperature, T', in the condenser, the latent heat, r', is rejected (A B in Fig. 7), then the liquid heat, $q'-q$, is given up at temperatures decreasing from T' to T (A E in Fig. 7). Entering the refrigerator, the ammonia abstracts from the brine the latent heat, r, minus the liquid heat just referred to. In this way the useful cold, $r-(q'-q)$, is produced just as in the compression machine.

The return from the temperature, T, to the temperature, T', is, however, not affected by direct compression. The vapors are not raised to the necessary pressure for liquefaction by the action of a piston, but in an indirect way by means of absorption and distillation. The same mechanical work is to be done in either case, only the nature of the performance is different. Instead of compression by a piston the volume σ of the liquid ammonia is transformed in the generator to the volume, v, by heating under the pressure, p', necessary for liquefaction, thereby the mechanical work, $p'(v-\sigma)$, is performed. This work is equal to that to be done in the compression cylinder.

The fact that in the absorption machine the work is produced by the direct application of heat makes the comparison with the compression machine somewhat difficult. The refrigerating machine and the motor may be taken as being combined in the absorption machine. For comparison with the compression machine the latter must be supposed to be driven by a heat motor, say a steam engine, and both, *i. e.*, the heat motor and the compressor, are to be considered as one unit side by side with the absorption machine. The question is now—How many heat units must be expended for the production of one thermal unit of cold?

For the compression machine we had:

$$\frac{A\,W}{H} = \frac{T'-T}{T}$$

It is well known that in order to produce the work, W, in a steam engine a far greater amount of heat has to be expended than A W, because only one part of the expended heat can be transformed in mechanical work. If, for instance, we have to deal with a steam engine with a consumption of 14 lb. of steam per horse power hour, the proportion of A W to the actual consumption of heat, H_s, will be about 1 : 6·33, and we have for the expenditure of heat to produce a certain amount of cold, H, the equation:

$$\frac{H_s}{H} = 6{\cdot}33\,\frac{T'-T}{T}$$

If the value of $\frac{T'-T}{T}$ is entered in a diagram (Fig. 11) as abscissæ (T' taken as 68° F.), and the value of H_s (H taken = 1) is entered as ordinates, we get a curve (*a b*) which represents the theoretical minimum of H_s. In a second curve (*c d*) were represented

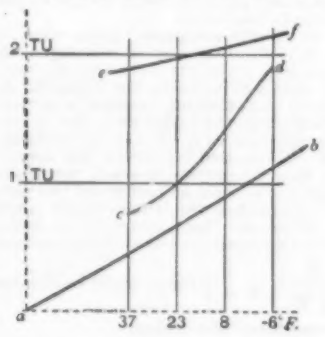


FIG. 11.

those heat units, H_s, which are actually measured in the ammonia compression machine tested at the trial station of the "Polytechnischer Verein" in Munich.*

How do absorption machines behave as compared with this result? We have seen: the cold produced per lb. of ammonia circulated is:

$$H = r-(q'-q).$$

In the generator, without considering the water carried through the process, heat must be expended as follows: The latent heat (r'), plus the heat of absorption (a), and plus the specific heat (c) necessary for the superheating of the ammonia vapors from the temperature, T' to ϑ'.

The result therefore is:

$$\left(\frac{H_s}{H}\right)\text{ min.} = \frac{r'+a+c(\vartheta'-T')}{r-(q'-q)}$$

If we now plot in our diagram (Fig. 11) the values of H_s, corresponding to the temperatures represented by the abscissæ, we get the curve (*e f*).

By comparison of these three curves, it is evident that the performance of the required mechanical work can be done much more economically in a compressor than by means of the system of absorption and distillation, even if an apparatus could be constructed for the performance of this working principle, working without any losses whatsoever.

In the discussion that followed Mr. W. W. Beaumont said they had to thank Professor Linde for a really valuable paper, containing a great deal of important information—the result of his own researches—though, at the same time, he did not know that it contained any striking novelty, or any points which he had not dealt with in previous papers. Probably many present would be better able to speak on the subject from the practical or commercial side, which had not been touched upon. Few probably had any idea of the magnitude of the traffic now carried on by cold storage vessels, or of the continually greater and greater extent to which they were looking to foreign countries for the supply of food to the country, owing to the use of such vessels. Refrigerating machines had been much more amenable to scientific treatment on the thermo-dynamic side than almost any other class of machines. They had long been accustomed to see steam engines and other motors submitted to this kind of examination, but he was not sure that the steam engine had been much improved in consequence; but it was perfectly clear that refrigerating machines had gained in every way by such treatment, as had been so ably described. The point referred to as the difference between latent heat and liquid heat was one which lay at the bottom of the most important recent advances, but without going into that he would ask to what extent recent practice had shown that the theoretical difference in economy between the different classes of machines had been borne out. Even now air engines were still being constructed, and quite recently he had seen a large set of them being prepared for a large ship; there must be some reason for continuing the use of machines which, theoretically, were so much less efficient than others. Of the two other kinds, again, each found supporters among people who apparently knew what they were about; and one would like to know whether they were practically as different as they appeared to be theoretically

Mr. E. Hesketh said the author of the paper had certainly added a very important contribution to the somewhat scanty literature on the subject of refrigerators, but he wished he had reconsidered his position before again committing himself to the statements he had made on the subject of carbonic acid. It was stated, and appeared by the diagrams, that the efficiency of carbonic acid was practically nil when the cooling water was at 88° F., but that was distinctly not the case, as was shown by the fact that there were at present over forty carbonic acid machines working constantly through the tropics, where the water was often higher than 88°, and they were working perfectly satisfactorily. He assumed the statements made with regard to carbonic acid were based on theoretical considerations and experiment, but they all knew how difficult it was to experiment with such matters as liquid carbonic acid or ammonia, and he could only conclude that an error had crept in somewhere. It had been suggested that such machines, when the water was at 88° or over, worked in the same way as an air machine, that the carbonic acid did not liquefy, but that some sort of action took place, similar to that shown on the diagram. The fact, however, that these machines were working through the tropics without any expansion cylinders whatever disposed of that suggestion, and showed that a similar action took place above 88° as below.

He had seen many machines at work when the water was at 100°, and still acting efficiently. One important point which had not been touched upon was the safety of the material used, and, in this respect, ammonia could not be compared with carbonic acid. Every one knew how poisonous and offensive were the fumes of ammonia, but, with carbonic acid, the whole contents of a machine might be allowed to escape into a room without any fear of deleterious consequences. One effect of that was this, that in designing a machine, it was absolutely necessary that on both sides of the compressor there should be stop valves, so as to be able at any time to open the compressor and bottle up the chemical in the evaporator and condenser. If, by any chance, the attendant neglected to open his delivery stop valve, the consequences would be very serious, but in the case of a carbonic acid machine, a safety valve could be put in at that point, while with an ammonia machine such a remedy would be almost worse than the disease. There was no evidence to prove that carbonic acid machines were less efficient than ammonia machines, and even if it were so, the greater safety of using the former should have weight in deciding which was best to use.

Colonel Cunningham said he had seen several ammonia machines at work where the temperature of the air was over 100° and that of the water was probably over 88°. The offensive smell of ammonia was a great protection in the case of a domestic machine, as it gave you warning something was wrong. The danger no doubt was very great in the case of an explosion. He knew of one case in which a machine was blown up, belonging to a brother officer, and though he was not injured by any of the fragments, he died within a day or two from the effects of the ammonia

Professor Linde, in reply to Mr. Beaumont, said the progress of the different systems showed that practice was quite in accord with theory. The ammonia compression machine was by far the most used now. The reasons for the exceptions were so manifold that he could not attempt to go into them. He did not think Mr. Hesketh could have followed his explanation of Diagram 9. He explained that when the carbonic acid was coming from the condenser at 88°, the critical point, or higher, the whole amount of latent heat was consumed by the liquid heat in reducing the temperature of the liquid carbonic acid; the same amount of heat was taken away as was gained by evaporation. Mr. Hesketh suggested that his figures were not right, but he could only say that no other point in the whole theory of heat had been the subject of so much scientific research during the last few years as the state of carbonic acid at the critical point. It did not follow that a machine would cease to act at that temperature, because, as he had explained, it was possible to go far below the temperature, T, with the vapors; and then to raise their temperature in the evaporator. When the carbonic acid entered the refrigerator it was in a state of saturated vapor; but if they were at a temperature of, say, zero, and the brine was maintained at a temperature of 23° F., then the temperature of the vapors could be raised in the refrigerator from zero to 23°, thus abstracting a certain quantity of heat from the brine, and so producing cold. That amount was represented by C D on the diagram. It was simply impossible to produce cold under such conditions with a smaller amount of work than the theoretically necessary amount represented by the whole area of the diagram. Cold air machines had brought cargoes of meat in very good condition through the tropics, and the carbonic acid was in a much better condition than air, because one pound of carbonic acid vapor took much more heat from the brine than a similar weight of air, its specific heat being much greater. It was a mistake to suppose that such a production of cold could not take place without an expansion cylinder. When air expanded from high pressure to low pressure it was necessary that it should do work on a piston, otherwise its temperature would not be diminished. If the air expands without doing work on a piston, then work is done on the air to give it a high velocity, which work might be termed living power. When it came to rest in the room, that living power was again returned in heat. In the case of carbonic acid, when it flowed from the condenser to the refrigerator, the work was not done outside, as in the case of the cold air machine, but internally; as the volume grew there were enormous internal forces at work, and the equivalent of this work replaces the outside work in the cold air machine. There was only one way of definitely settling such questions and that was by public experiment. In Munich there was a large testing station to which manufacturers were invited to send their machines for trial by a commission consisting of the highest authorities in Germany, Professor Zeuner being president. The tests were made in the presence of the commissioners and of the competitors, so that the results were perfectly trustworthy. The safety of different systems must be judged by experience, and the way to test them would be to take the number of machines made on each system and multiply them by the time they had been in work, and then ascertain how many accidents had occurred in each. In that way a fair comparison could be made. The result would show that carbonic acid was much more dangerous than ammonia, the reason probably being that the working pressure was from six to eight times larger. He knew of at least three accidents with carbonic acid machines; one occurred at Bar le Duc, where the attendant was killed by the explosion of the cylinder; one at Guinness', in Dublin, where no personal injury was sustained; and one in a vessel at Buenos Ayres, where a carbonic acid bottle exploded when it was being used to charge the machine, and two persons were killed. There were probably 40 times as many ammonia machines at work as there were of carbonic acid, and they had been working at least three times as long, so that there ought to be 120 times as many accidents in order to show that they were equally dangerous; but he did not believe it would be possible to find even 40 or 50 such accidents.

[Continued from SUPPLEMENT, No. 953, page 15225.]

WATER TUBE BOILERS.*

IN our last impression we sketched in Fig. 10 a form of header, and we stated that, so far as we knew, no boiler was constructed precisely in that way. It is proper to point out before going further that in saying this we referred only to land boilers. The latest type of Lagrafel-d'Allest boiler, constructed for marine purposes by the Forges et Chantiers de la Mediterranee, almost complies with our description. A sketch of this boiler will be found in Mr. Milton's paper read before the Institution of Naval Architects, at Cardiff, and published in our issue for July 21, 1893.

The object had in view by designers of express boilers is the production of a steam generator which shall be as light and as small as possible for its power. We shall have a good deal to say further on this branch of our subject; but for the moment our business is not with weight or dimensions, but with the special features or characteristics of express boilers. Generally speaking, all boilers of the kind have tubes of comparatively small diameter. There are three prominent varieties. First, modifications of the Root type, under which head may be included the Belleville boiler, a sketch of which as used in the French navy we give in Fig. 10*, and some others with tubes smaller and shorter than those of land boilers; all these bear forcing moderately well, but they are not express in the full sense of the term. Secondly, coil boilers of various types, such as the Herreshoff, which stand forcing very well. And lastly, express boilers in the full sense of the word, of which those of Thornycroft, Yarrow and Normand are the best known.

It is not, we think, necessary to dwell at any length on the Belleville boiler, because nearly all that we have already said applies to it and to its congeners with more or less pertinence, and our readers will not be slow to understand in what way it is better or worse in principle than other water tube boilers of this type. The coil boilers are peculiar, and require explanation. The use of coils has been common enough. Coiled tubes present a great deal of heating surface in a small space. They are used either with or without steam drums or their equivalent. When combined with a drum the coils are usually short; sometimes, indeed, the so-called "coil" is little more than half a turn of tube. Several coils may be combined with a central drum which they surround. In fact, the ways in which they may be arranged are almost endless. On the whole, however, boilers of this kind do not appear to be very satisfactory. To some extent the free rush of water and steam through them is hampered, and the tubes are punished in the bending. Certain it is that various boilers of this type have given trouble by splitting their tubes, and these are not easily got at for plugging or repair.

However, all boilers of the kind of which we have knowledge possess the advantage secured by letting each tube have a free delivery into the steam drum, so that fighting between two tubes never can occur. Undoubtedly, however, the best type of coil boiler is that in which the whole of the heating surface is disposed in a very small number of tubes. It is clear, however, that these tubes must be very long. Roughly speaking, each foot in length of a 2 in. tube represents half a square foot of surface. To get 500 square feet we shall need a tube 1,000 ft. long. Such tube disposed in two sets of coils would give a boiler not more than 7 ft. in diameter by about 8 ft. high, and each square foot would probably evaporate 10 lb. of water per hour, so that with a triple expansion engine the boiler would supply steam for 500 or 600 horse power. But those who have read what we have already said concerning circulation will readily understand that, inasmuch as the coils of pipe must be nearly horizontal, it would be impossible to get sufficient natural circulation through a pipe of such enormous length.

Coil boilers of this class therefore have been almost

* See "Bayerisches Industrie and Gewerbeblatt," No. 25, 1893.

* From the *Engineer*, London.

invariably worked with forced circulation, a pump driven by the engine forcing water continually through the tube. John Elder's boiler, patented in 1862, is one of the early examples of the type. He used a spiral fan or propeller to drive the water in at the top of a tall coil. The steam and water escaped at the bottom into a vertical drum considerably taller than the coil. The upper part of this drum was the steam space. Fig. 11 will suffice to indicate the general features of the arrangement. A is the propeller and B is a pulley driven by a belt from the engine. As far back as 1824, Paul patented a boiler of this type, with a force pump to maintain circulation. The water entered at the upper end of the coil and steam was delivered at the bottom. No attempt was made to provide a steam drum, as the inventor proposed that all the water should be converted into steam before it escaped from the lower end of the coil. Benson's boiler, which made some stir at one time, was a coil boiler with forced circulation, patented in 1858. Since those days many other boilers have been made by various inventors, among whom may be mentioned Herreshoff and Yarrow.

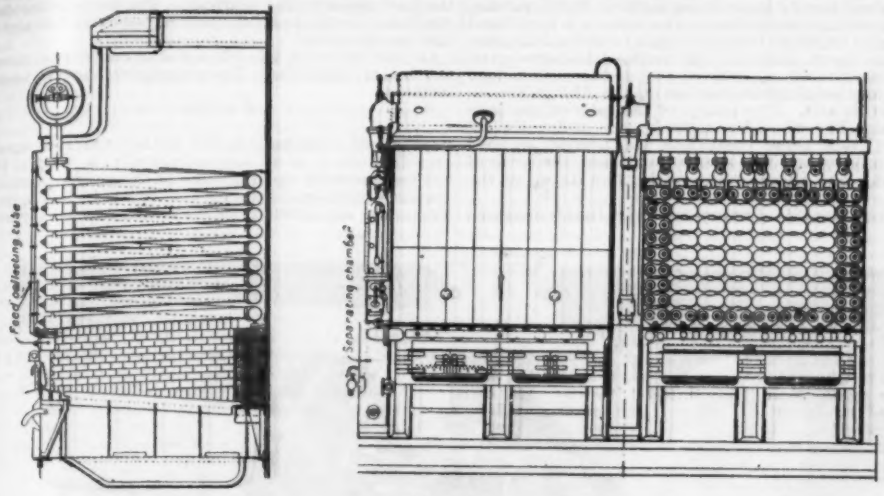


Fig. 10a.

This type of boiler has never yet, we think, had justice done to it. Under proper conditions it is capable of unlimited forcing, being indeed an express boiler in the fullest sense of the term. But it is open to considerable objections on the ground that a small failure in any part of the length of the tube renders the whole boiler *hors de combat;* whereas in boilers with many tubes, if one is burst it may be plugged, and the boiler is then capable, after a little delay, of working as well, or nearly as well, as before. For small boilers for steam launches, however, the system ought to work very well, especially as there is no delay in getting up steam; a pressure of 120 lb. can readily be had in a quarter of an hour, and the boiler is quite safe in that a split tube is most unlikely to cause an accident. It would be quite possible to adapt the principle to larger powers, by using a number of coils instead of one, the circulation being maintained by a single pump. This will have very little to do, the pressure being very nearly the same on both sides of the piston. We have already described a modification, however, when some work would be thrown on the circulating pump, the steam and hot water being delivered into the drum under pressure. An objection to coil boilers without water drums is that the pressure is very unstable, flying up and down from minute to minute as the fire varies. It is usual, therefore, to load the safety valve to considerably beyond the working pressure to allow a margin. Although not strictly a water tube boiler, in the sense in which the words are used in these articles, we cannot omit mention of the Serpollet boiler, illustrated by Fig. 11*a*, which is a plan. It consists of heavy cast iron blocks incasing a steel tube flattened until the opening through it is less than one-twentieth of an inch wide. Water is pumped through this, and converted into superheated steam. We have already fully described the steam carriages to which M. Serpollet has applied his boiler with much success.

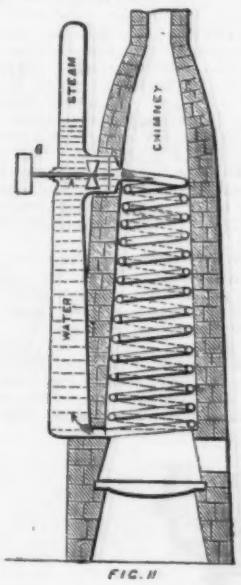
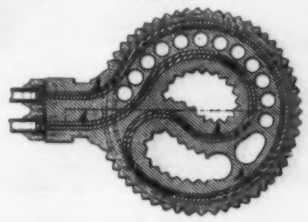


FIG. 11

We have said that the modern express boiler is a new departure in engineering, and we think the fact will be fully recognized before we have done. It is the result of the labors of two engineers, Mr. Thornycroft and Mr. Yarrow. In certain respects their boilers are alike, in others totally distinct. We shall begin with the Thornycroft boiler, which was indeed first in the field.

There are several distinctive and original features in the Thornycroft boiler. It consists essentially of a central horizontal steam drum, two horizontal water supply tubes, and a number of small diameter tubes uniting the others. The first point to be noticed is

Fig. 11a



that instead of a number of tubes discharging into a single header or riser, which in turn opens into the steam drum, each individual tube opens directly into the steam drum. Thus each tube acts for itself, and cannot fight with its neighbors for precedence in delivery. The tubes are long, but they are of small diameter—about 1 in. inside—and they are made of a very special soft steel. We have no intention of describing here the methods of manufacture. Fig. 12 shows the principle.

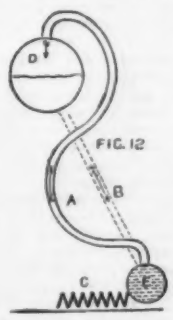


FIG. 12

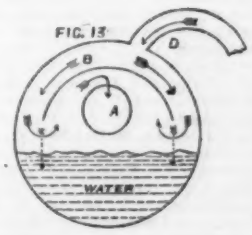


FIG. 13

We have shown only steam-making pipe, A, and one down pipe, B; the grate is C. One of the first points to be noted is that the tube, A, enters the drum, D, at the top. A very great quantity of water is carried up with the steam. If the steam and water entered at the bottom of the drum, they would cause a violent commotion; by coming in at the top the water is projected downward, and separated by its momentum from the steam. The anti-priming arrangement inside the steam drum is very simple; it is shown in Fig. 13. Here A is the steam pipe which runs from end to end of the steam drum. It is provided with saw cuts all along the top; B is a deflector plate—a pent-house or roof, in fact, over the steam pipe, on which is delivered the rush of steam and water from the tubes, one of which is seen at D. The water is thus knocked out of the steam and falls straight down, as shown by the dotted arrows. The scheme is quite effectual, and the boiler supplies dry steam. At first sight it would appear that a boiler of this kind must have a steam drum, D, Fig. 12, and "feeders," E, of sufficient diameter to permit a man or, at all events, a boy to get inside in order to fix the tubes in D and E.

Obviously this would limit reduction in dimensions. To Mr. Thornycroft, however, is due the credit of so contriving matters that tubes as small as 10 inches in diameter can be used for E. A special roller tool is used, which can be introduced through the end of E, which is fitted with a removable lid. The roller tube expander, carried on the end of a staff, can be put in place, and worked by a ratchet gear; the tubes being secured by rolling with almost as much ease, and nearly as quickly, as though direct access could be got to them. This may appear at first sight a small thing, yet it is nothing of the kind. The fact that it is possible to secure tubes in this way, and to make water and steam tight joints at a distance of 5 feet or 6 feet from the operator, is one of very great importance, and, in certain respects, revolutionizes the construction of tubulous boilers. When we come to consider the question of weight, it will be understood what the innovation really means. The success attained by Mr. Thornycroft stimulated invention in the same direction, and numerous patents have been taken out, especially in the United States, for boilers using small tubes combined with feeders and drums. Fig. 14, patented by Messrs. McBride & Fisher, of Philadelphia, has been fitted to a large launch which has attained a very high speed, and great success is claimed for the generator, concerning which we shall have more to say. It will be seen that it very closely resembles one side of a Thornycroft boiler. Fig. 15, another American boiler, speaks for itself. Fig. 16, although a land

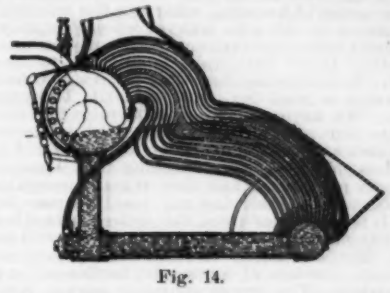


Fig. 14.

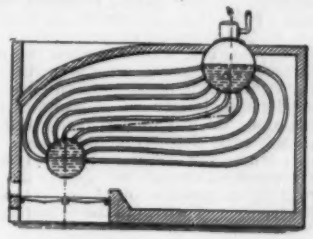
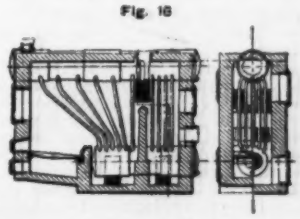


Fig. 15.

boiler, involves much the same general principle of construction.

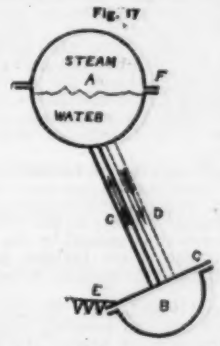
The Yarrow boiler has certain features in common with the Thornycroft boiler. Thus, it consists of a central steam drum above and two water feeders below, united by the steam generating tubes, which are of small diameter; but here the resemblance ceases. Following the plan we have adopted with the Thornycroft boiler, we only give in the annexed sketch a single tube of the Yarrow boiler. Here A is the steam drum. B a feeder, C a generating pipe, and D, dotted, is one of two or more down-flow pipes, E is the grate.

Fig. 16



The steam drum has a horizontal bolted joint all round, and the water feeders consist each of a flat tube plate and a semicircular lower half bolted together. In this way access is got to both ends of the tubes. Indeed, the tubes and the upper plates of the feeders, and the lower half of the steam drum, are put bodily into a galvanizing pot and coated all over with zinc to prevent that external corrosion to which all boilers of this type seem to be liable when not in use. This has been a very successful steam generator, and, although the pipes deliver into the lower portion of the drum, the boiler supplies very dry steam to the engines, special precautions being taken in fitting the steam pipe to attain that object. So far as can be seen there is nothing to choose between the Yarrow and the Thornycroft boilers as steam makers. In attempting to arrive at a conclusion respecting the relative merits of two different boilers, it is impossible to ignore the surrounding conditions. We shall show in a subsequent article that express boilers are mainly judged—other things being equal or nearly so—by their weight. The lighter the better. Now one of the very first points to attend to in designing a light boiler is to avoid the use of any heating surface that falls in efficiency below a certain minimum. Putting this in a different way, it amounts to saying that no generating tube should have any portion of its length non-efficient. If we compare the Yarrow and Thornycroft boilers, it will be seen that the tubes in the former are shorter than those in the latter. If we suppose the weight of the boiler to increase or diminish precisely as the length of the generating tubes increases or

Fig. 17



diminishes, then the Thornycroft ought to be heavier than the Yarrow boiler for a given power, unless it can be shown that each foot of length of tube is as efficient in one as in the other. It is clear, however, that this cannot be the case, because the upper portions of the Thornycroft tubes are far removed from the fire. We have no means of knowing what are the weights per horse power of the two boilers; we suspect they are very nearly alike, but that must obviously be because some other factor than tube length has to be considered. Thus it seems clear that the Yarrow feeders must weigh a good deal more than the Thornycroft feeders. We have used these boilers in this case to illustrate our proposition. The point is constantly overlooked, and we find in some boilers intended to be as light as possible, surface weighing from 5 pounds to 20 pounds per square foot that is really incapable of generating steam or serving any good purpose whatever. It is sometimes urged that unless surface is supplied the evaporative economy of the boiler will be reduced. This is a matter of small consequence in express boilers, unless, of course, the inefficiency is very well marked. The proper course to pursue is to decide upon some one coefficient, and to work that. Thus we may decide that no surface shall be held worth having unless it will evaporate 3 pounds of water per square foot per hour. But of course any other coefficient may be selected. Again, the boiler designer must never forget that mere proximity to the fire or the reverse does not alone fix the rate of evaporation or the economy of fuel. It will be time enough to enlarge on this point, however, when we come to speak of the way in which the heat is supplied, applied, and distributed in water tube boilers.

We have now, we think, shown in what lies the main difference between the express and the ordinary water tube boilers. In brief, it consists in the use of small tubes of considerable length in proportion to their diameter, and more or less nearly vertical, in the express boiler, each tube delivering independently into a steam drum; while the ordinary water tube boiler has tubes of larger diameter, set nearly horizontal, and delivering in quantities of eight or twelve into headers or risers, each of which delivers into the steam drum.

The adoption of the small tube system, and the success which has attended it, has, as we have said above, stimulated further invention, and many boilers are proposed or being made which more or less resemble the Thornycroft and the Yarrow steam generators. Among these may be mentioned the boilers made by M. Normand, of Havre. Furthermore, the principle is being adopted in boilers for ordinary marine service under conditions which do not dictate minimum weight. It is by no means probable, indeed, that invention has nearly covered the whole ground, and it is not impossible that something better may yet be produced than anything now in the market.

(To be continued.)

DE LAVAL'S STEAM TURBINE.

In every disinterested and impartial mind it is now well established that the days of the ordinary steam engine are numbered.

From the standpoint of the conversion of thermic energy or heat into mechanical energy work, the modern gas engine is already infinitely superior to it, since it converts 16 per cent. of the heat that it receives into mechanical work. The best organized steam engine attains half such a result with difficulty. With equal calorific power the high price of illuminating gas is the sole obstacle to the substitution of the gas motor for the steam engine; but tentatives have already been made, with success under certain circumstances, to substitute for illuminating gas poor gases obtained directly in special generators, and to suppress the use of steam. Under such conditions, one horse power has been obtained upon burning 20 ounces of anthracite with a motor of 75 horse power only—a consumption to which it would be impossible to descend in employing the most improved steam motor. The steam engine is therefore no longer the best thermic motor known and constructed.

But even in accepting steam as the necessary intermediary between the heat developed by the combustion of coal and the work to be produced upon a shaft, the ordinary process of conversion by engines having cylinders, pistons, connecting rods, cranks, eccentrics, rods and distributing slide valves seems superannuated to some. For some years there have been constructed and employed upon a large scale rotary motors of high angular velocity (from 6,000 to 12,000 revolutions per minute), in which the expansion of the steam in a series of turbines produced the revolution of the shaft directly without any of the parts that we have just enumerated. The Parsons turbine is the best known and most widely distributed motor operating under such conditions.

But there was still one step to be taken in this direction. Instead of effecting the expansion of the steam in the motor itself, why not utilize such expansion for communicating a great velocity to the steam and utilize the kinetic energy thus gained by the latter for directly actuating a true steam turbine, just as water actuates a hydraulic one through its velocity and kinetic energy?

This step has now been taken. Mr. De Laval's turbine, which we are going to describe, realizes precisely the conditions enumerated above. It consists of a bucket wheel, with a horizontal axis, the buckets of which are struck by the steam coming from the boiler and possessed of a great velocity due to its previous expansion in an ajutage properly widened out to this effect. The steam communicates its kinetic energy to the buckets and escapes through the other face at a reduced velocity. The general principle of action is the same as that of hydraulic turbines. The steam must enter without shock and make its exit without velocity, in order that the apparatus shall be placed under the best possible conditions of rendering.

The body of the turbine consists of a slender steel shaft upon which is mounted a steel disk upon the periphery of which are formed the buckets upon which the steam acts (Fig. 1). The disk is surrounded by a steel ring designed to close the buckets of the turbine, prevent vortices of steam and suppress the resistances that would be met with by the ends of the buckets in the atmosphere, being given the great velocity (from 500 to 650 feet per second) that is communicated to them. The disk revolves in a cast iron chamber, one of the sides of which serves for the entrance of the steam through one or more ajutages. The other serves for the exhaust. As the angular velocity of the wheel is very high (from 15,000 to 30,000 revolutions per minute, according to the power), it is reduced in the ratio of 10 to 1 through a pair of helicoidal gearings whose teeth, inclined at an angle of 45 degrees and in opposite directions, assure a very gentle motion and prevent any longitudinal motion of the disk in the direction of its axis. The pinion of this pair of gearings is of steel. The wheel has a steel nave and a rim of bronze. Under these conditions the friction is steel against bronze, and this spares the pinion, the teeth of which do ten times more work than those of the wheel.

It is upon the axis of reduced velocity that is mounted the centrifugal force regulator, which acts upon the admission through the closing of a balanced valve placed at the entrance of the steam into the apparatus.

The power of the apparatus is made to vary by opening a variable number of ajutages, so that the same motor is capable of operating under very favorable conditions of power, while at the same time preserving sensibly the same rendering.

As the steam acts only by its velocity, and not by its pressure, since it is expanded before acting, and escapes at nearly the pressure of the atmosphere or at that of the condenser, there may exist between the bucket disk and its jacket a play of 0·08 inch, so that no friction of metal against metal occurs other than that of the anti-friction metal pillow blocks, which, moreover, are of small diameter and long range.

The steam turbine of 10 horse power that we shall take as a type is but 36 inches in length, 19 in width, and 34 in height. Its weight does not exceed 440 lb. The axis of the turbine runs at the angular velocity of 24,000 revolutions per minute—say 400 per second. The steel disk is but 5·25 inches in diameter and 0·5 inch in thickness. Its periphery thus moves at a velocity of 577 feet per second. Under such conditions, the tangential stress upon a circumference of 2·75 inches radius is scarcely more than 8·8 lb. when the machine is producing its 10 horse power, and this justifies the small dimensions of the driving shaft, the diameter of which does not exceed 0·3 inch in the part comprised between the disk and the pinion, and but 0·2 inch in the part opposite the gearings. The parts of the shaft revolving in the bearings are respectively 0·46 and 0·3 inch in diameter.

On the contrary, the effect due to centrifugal force is much more important. Upon applying the well known formula

$$F = M\omega^2 r$$

in which M is the mass and F the force exerted upon it at a distance, r, at an angular velocity, ω, we find that the force exerted upon a mass of 15 grains placed at the circumference of the turbine of 2·75 inches radius is 96 pounds, say 44,000 times the action exerted by gravity upon such mass. In the more powerful types, the centrifugal force exerted upon a mass of 15 grains exceeds 110 pounds. It will be conceived that, under such conditions, the least defect in the centering or in the homogeneousness of the material would produce lateral stresses and vibrations at the expense of the silent running of the turbine and of its rendering. This difficulty has been very ingeniously overcome by Mr. De Laval by mounting the disk upon a long and elastic shaft capable of undergoing a certain flexion. If, under the action of the unequally balanced masses, the disk tends to become eccentric, the flexible axis twists slightly and through its torsion brings back the center of gravity to the real axis of revolution. The defect in symmetry is thus automatically compensated for.

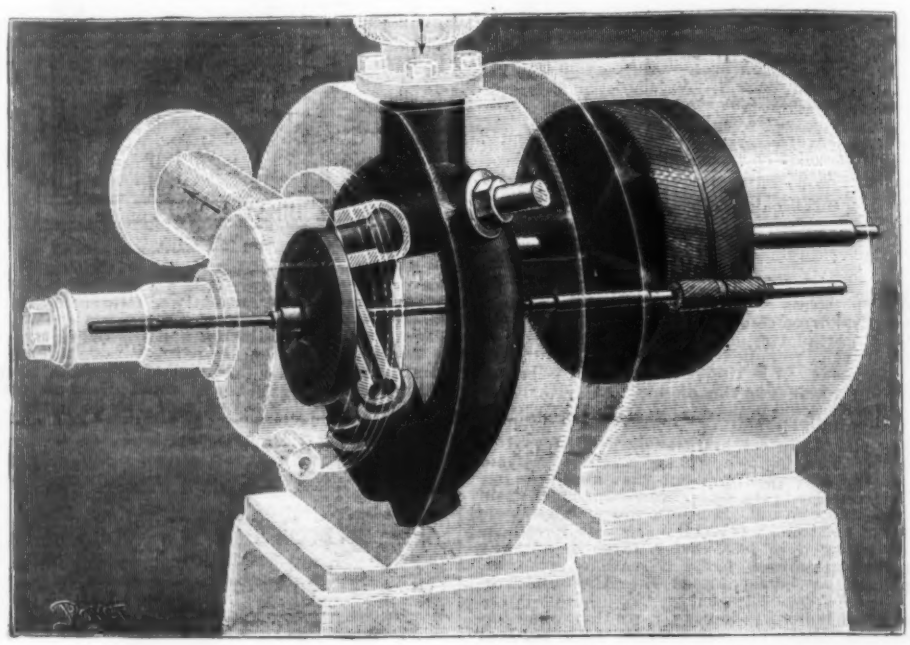


Fig. 1.—THE DE LAVAL STEAM TURBINE.

The jacketing of the motor and gearings is supposed transparent in order to allow the essential parts of the system to be seen.

Fig. 2 shows an application of the steam turbine to the running of a dynamo (Manchester type) making 2,400 revolutions per minute. The weight of the whole turbine, gearings and dynamo, is less than 1,300 pounds for an effective 10 horse power.

In powers exceeding 20 horse, the pinion actuates two toothed wheels placed symmetrically on each side of the axis of the turbine properly so called, and in the prolongation of the axes of these wheels are mounted two dynamos of equal power that may at will be

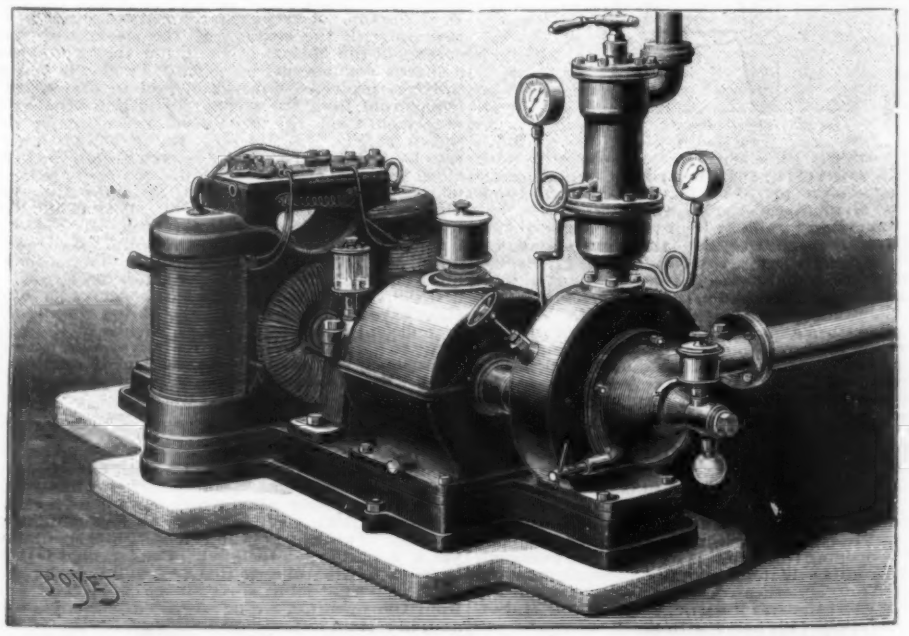


Fig. 2.—TEN HORSE POWER STEAM TURBINE DRIVING A DYNAMO.

coupled in tension—an arrangement just the thing for small central stations that distribute electric energy with three wires, or in quantity, if the distribution is made with two wires.

In consequence of the great angular velocity of the steam motor, the system as a whole presents proportions the reverse of those to which we are generally accustomed. It is the motor which has by far the smallest dimensions; then come the gearings, with their cast iron jacket, and finally the relatively reduced angular speed dynamo.

When the steam turbine is to actuate anything else but a dynamo, the extremity of the shaft of the toothed wheel carries a pulley over which passes a driving belt.

Seeing the great velocity of this belt (80 feet per second), it is well to make it without joints and provide it with a tightener.

The advantages claimed in favor of this motor are its simplicity, the small space that it requires, the absence of foundations and parts in friction aside from the pillow blocks, the regularity of running due to the constancy of the motive couple, and the ease with which a condenser may be adapted.

The consumption of steam does not exceed that of ordinary motors of equal power, while the cost of lubrication, there are no less than a hundred apparatus in service in the Scandinavian peninsula, varying between 5 and 100 horse power. Three hundred horse power types are now under study and will soon be constructed. A French company, the Societe de Laval, has just been organized under the superintendency of Mr. Sosnowski, and has intrusted the construction of its machines to the Breguet establishment, where, thanks to the politeness of Mr. G. Sciama, we have been enabled to examine the so simple, so interesting, and so original apparatus that we have just brought to the notice of our readers.

A dozen years ago, steam engines were of so low speed and dynamos of so high, relatively, that it was often necessary to establish two intermediate transmissions before it was possible for one to actuate the other; but, step by step, we at length succeeded in employing but a single intermediate transmission, then a direct driving by belts, and finally a direct coupling, the dynamo being mounted in the prolongation of the motor's axis; and the angular velocity of steam motors ever kept increasing. It even increased so rapidly that the Parsons turbine, which made from 9,000 to 12,000 revolutions per minute, had to descend to 6,000 revolutions in order to be able, industrially, to actuate directly coupled dynamos; and still the angular velocity of steam motors kept increasing, so that to-day, with the De Laval turbine and its 24,000 revolutions per minute, a train of reducing gearings becomes indispensable. The steam motor revolves too rapidly and the dynamo not rapidly enough. In twelve years, the evolution of progress has reversed the terms of the initial ratio. This fact ought to render us prudent and reserved.

The De Laval turbine has warm and enthusiastic partisans, as it has bitter detractors. This is the fate of all new things, and we have recently had another example of it apropos of the Heilmann locomotive. For one as well as for the other let us be content to register the facts acquired, and patiently await the data of experience, the only master that never deceives and is never deceived.—*E. Hospitalier, in La Nature.*

THE STATE DAM, MOHAWK RIVER, AT COHOES, N. Y.

THIS work is known as the "State dam," in contradistinction from the dam of the Cohoes Water Power Company, located about a mile above the falls, and by its means and a bridge the boats on the Champlain or Northern Canal are enabled to cross the river, which at this point is 1,700 feet wide. Several previous dams built here have been carried away.

Fig. 1 shows the method of constructing the apron. Strong ribs grooved on their inner edges are secured by braces to the masonry of the dam and then sheets of iron are introduced between the ribs, as shown in our engraving. The lower half of the apron is first built and the space between the iron plates and masonry filled in solid with concrete cement, then the upper half is made in the same manner and the cement carried up behind the iron plates to the top.

The top of the dam is finished, as seen in Fig. 2, by laying strong girders, which are firmly anchored to the masonry coping, and upon the girders iron plates are attached, the interstices between the girders and covering plates being solidly filled with hydraulic cement or concrete. The whole work is of the strongest and most substantial nature.

FIG. 1.—THE IRON APRON.

FIG. 2.—SHOWING THE TOP FRAME.

FIG. 3.—BACK VIEW OF GIRDERS.

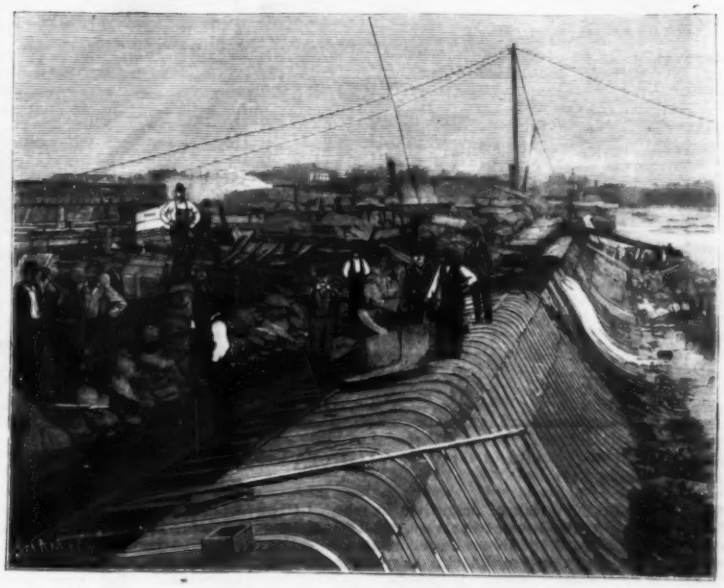


FIG. 4.—PLATING OF TOP GIRDERS AND APRON.

THE NEW YORK STATE DAM, MOHAWK RIVER, AT COHOES, N. Y.

The dam is built by Messrs. Cunningham & Morety, under contract with the State, the price to be paid being $90,000. For the photographs from which our illustrations are made we are indebted to Mr. Chas. McGovern, of Cohoes, N. Y.

ORANGES AS SOAP.—Housewives in Florida scrub their floors with oranges. In almost any town in the orange-growing districts women may be seen using fruit exactly as we use soap. They cut the oranges in halves, and rub the flat exposed pulp upon the floor. The acid in the oranges does the cleansing, and does it well, for the boards are as white as snow after the application.

A RAILROAD OVER THE NEVA.

WHEN winter has bound the beautiful broad Neva in its chains, it is the scene of greater activity than when free from ice. Good courses are laid out for skaters, Laplanders settle on it with their tents and reindeer, and various means of communication are opened to take the place of steam and other boats used in summer. It is well known that St. Petersburg has too few bridges across the Neva, an inconvenience that is much felt in summer, but in winter nature throws ice bridges over it, only a little aid being required from the hand of man. Wagon roads extend diagonally over the ice from many parts of the quay, being marked off by evergreen trees, and these relieve the bridges of much traffic, and sometimes save a detour of several wersts. Footpaths are laid out and lighted at night by lanterns, and near by

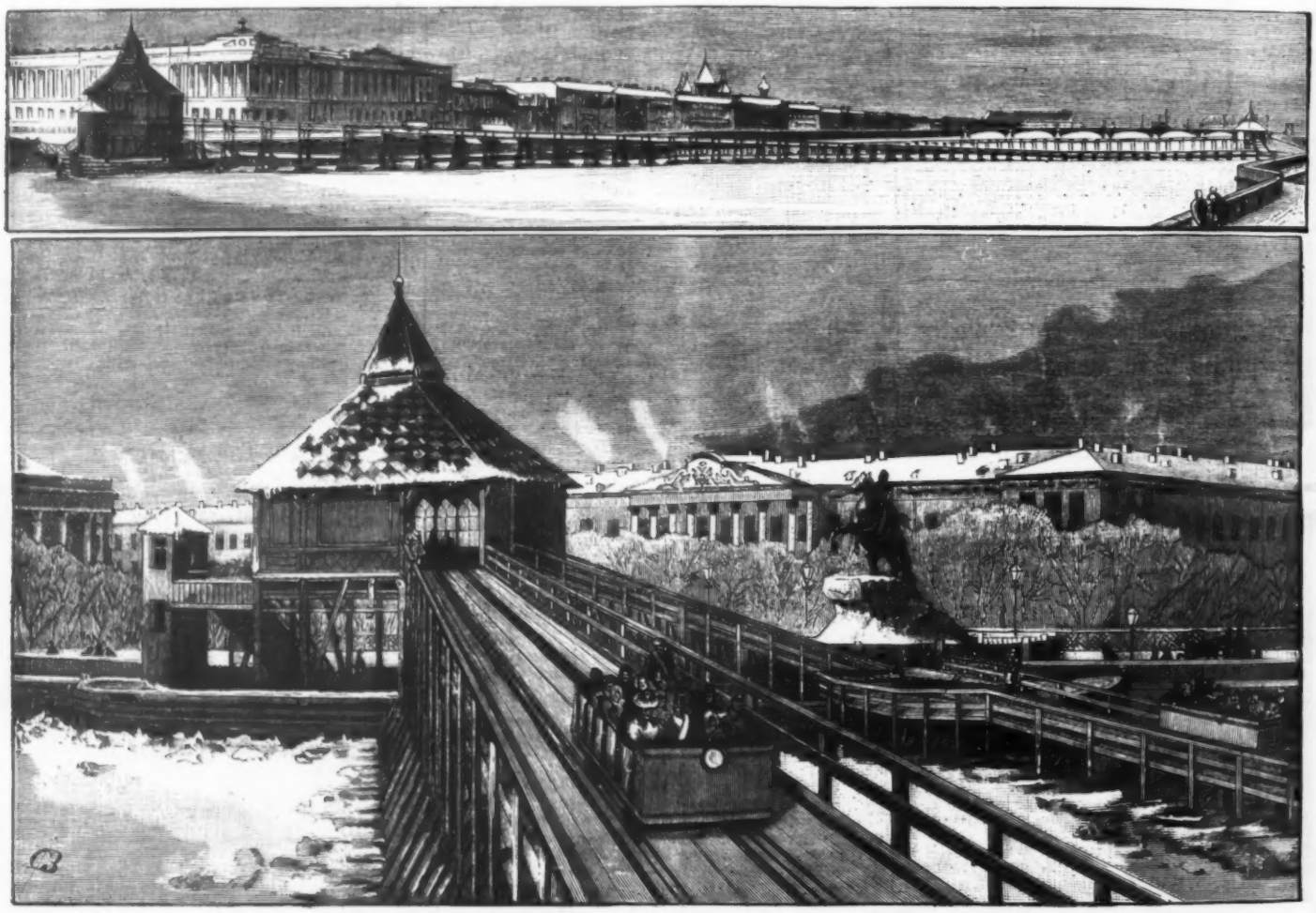
there are roads over which passengers can be taken in sleds pushed by men on skates.

This year a gravity road was opened by the energetic Finnische Passagierdampfer-Gesellschaft, the company which keeps steamboats on all the rivers and canals of the city and its suburbs from spring until late autumn.

There is a high tower on each shore, and from each of these towers runs a structure for a gravity road, reaching the opposite shore at a level with the quay. These structures rest on more than a hundred supports, which, in turn, are fastened in a frame of beams that rest directly on the ice. Rails are laid on the floors of these bridges, on which the broad, low cars run on small wheels. These cars are controlled by brakes. Each car can accommodate twenty passengers, and when it is time for a car to start it is pushed out of the room in which they stand upon the inclined track, and in less than a minute it rolls by gravitation across the Neva to the tower on the other side, where the brakes are applied at the proper time and the car is caught by two other guards. The distance covered is about half a mile.

The thing is very simple, but cost a great deal—about $9,000. The work consumed a great deal of time and a large quantity of wood was required for the structure. The unusually warm winter delayed the work, the ice not being uniformly secure. As many experiments and improvements of the track were necessary, the road could not be opened before the middle of January. It is very popular and meets with great encouragement; so much so, in fact, that any one who is in a hurry prefers not to go by the road, for he runs the risk of standing in front of the ticket office up in the tower for an indefinite length of time. Many enjoy the ride so much that when they have once started they make the trip several times. The fare is very cheap—about 1½ cents.

It is a question whether the receipts for this year will cover the expenses. The road certainly does not improve the appearance of the Neva.—*Illustrirte Zeitung.*



A RAILROAD OVER THE ICE OF THE NEVA, ST. PETERSBURG.

HOW WAR VESSELS ARE PREPARED FOR TRIAL.*

By ROBERT W. PECK, of New York.

MEMBERS of the Marine Engineers' Beneficial Association in Cleveland were favored, at their last meeting, with an address by Robert W. Peck, a gentleman who is well known to marine engineers and ship builders in the East, as he has acted in the capacity of superintending engineer on the trial trips of nearly all of the United States cruisers other than those built by the Cramps. Mr. Peck's duties in Cleveland at present are of a similar nature in connection with the preparations for bringing out the Northern Line passenger steamer Northwest. At the same meeting, Mr. G. L. H. Arnold, who is associated with Mr. Miers Coryell in looking after the construction of the Belleville boilers, read the paper on this type of boiler, which was prepared a short time ago by J. A. Courier, engineer of the yacht Wild Duck, and which was printed in the last issue of the *Review*.

Mr. Peck's paper, or address, was not one of a formal kind. It was more of an interesting talk to the engineers, and pertained mainly to his experience in preparing war vessels for the trials in which premiums or penalties are involved. Stripped of the introduction, which had reference to the nature of contracts for war vessels, and a few other parts dealing with the calling of engineers in general, it is as follows:

"As engineers, the matter which I think most interests you is the management of the engine department of these cruisers while preparing them for trials. The record obtained during these trials, whether speed or horse power, goes with the ship, and all of the vessels with which I have had to do when making these trials can, I think, by proper manipulation, do the same or even better again, at any time before age or other causes shall have weakened the elements used to make the trials. To be employed by the contractor you must have a reputation as an expert in that particular kind of work, as money is at stake with the builder as well as his reputation. You will understand that, although these engines are designed by able men, whose work is as near perfect as they can make it, it does not follow that the work of the machinery will be entirely satisfactory. On this account your knowledge and skill will be wanted. If you meet the requirements, you will probably be well remunerated for what you do. If you do well, it generally follows that the contractor is pleased, and that he will not forget to show you that he appreciates the favor you have done him by being the means of replenishing his bank account. The short way to say this is that you must be able to know what to do to make the machine do the most, and to make any changes necessary for such performance. My experience has been that some alterations are necessary in several of the parts before it is possible to get a satisfactory performance, and I have come to the conclusion that this is to be expected. I have found it with engines I have designed myself. I have said that you must be able to make these changes. That it is well for you to be able to do so as an engineer, there can be no doubt, but will the contractor or the owner permit you to do so? It would seem that if he had confidence enough in you to employ you for such an undertaking, he would trust to you to use your own judgment. In my experience I have found that when I came to the turning up of the engine and it was necessary to alter any of the parts, the leading men of the different companies were opposed to anything in the way of an alteration and it was necessary to do considerable talking to gain a point in that direction. This is one of the disagreeable features of such trial trips, but usually by keeping your head level you will get along very well, and before the time for the final wind up, which is the official trial, you will have your machine mostly as you wish to have it. After having come to an understanding with the contractors as to what you are to do and settled all minor questions as completely as possible, you will first obtain a suitable crew of men. A proper selection is absolutely necessary. They must be cool-headed, fearless fellows, and it is particularly desirable that they be not afraid of steam, so long as it does not reach them. I have found some trouble in obtaining suitable men for this kind of work, but the preliminary trial often proves them and they go away.

"Now we are supposed to have got aboard the cruiser with assistant engineers, oilers, water tenders and firemen in numbers sufficient to run the machinery for four hours, and then the training begins. The engines and all auxiliary engines and boilers are now supposed to be complete with every appliance in place, oil service and water service ready to receive the oil and water. All instruments are up ready to be used to take data of the performance of different factors that are to combine to obtain an intelligent knowledge of the trial, from which a proper report can be made. First a proper and thorough examination of all parts of the boilers and engines must be made. The grate surface is to be measured correctly, as well as the air opening in grate, area of opening into the combustion chambers, area of opening through tubes, area of opening out of uptakes and area of smoke stacks, and the bracing of boilers and position of valves and pipes entering and leaving the boilers must have careful attention. The dry pipes are very important factors and require the closest kind of examination, for it is important that the steam be dry, and with this these pipes have much to do. The separators must have a proper examination, and the steam traps attached to them must be in the best of order and should be of the best kind. The engines, too, are being carefully examined. All bearings are taken apart, cleaned, adjusted and oiled; cylinders are opened and carefully examined, and pistons and their packings are looked over carefully. Valves are taken out, measured, taken apart and cleaned, put back, and careful readings taken of their functions. All piping has to be carefully looked over to see that it is properly run, and that it is provided with slip joints wherever it is necessary, and that it is so run that it will not be subjected to any undue strain, from any cause that in any way probable might occur.

"All the leading men must make themselves perfectly familiar with all valves about the engine and boilers, and this is not a very small matter, for the number is large, and although they are all marked, time is required to learn them thoroughly and it is important that the right valve is handled at the right time. Having done with the examination, we will proceed to fill the boilers with water. When full we will warm them by starting some fire. Then the testing is to be done. I usually test to at least 50 per cent. more pressure than what I intend to use on the trial. The safety valves are now adjusted to retain a pressure about 20 pounds greater than I wish to use on the trials. All this work, bear in mind, is to be carefully done, for the success of the trial depends very much upon how thorough you have been in getting ready, and it is always well to keep in mind that it is a very small thing that may stop the trial and add to the general cost of getting the cruiser to the final stage of completion.

"We are now far enough advanced to get steam on the boilers and to commence to run the engines. The fires are lighted and allowed to burn slowly, in order that the expansion to the boilers and pipes may be as even as possible. If we have a small boiler, we use it to run pumps for the purpose of circulating the water in the boilers, which is a very good way to overcome the evil effects of unequal expansion. When steam is made of sufficient pressure, the circulating and air pumps are started, the vacuum is obtained and then the main engines are warmed up in a careful manner and started slowly. The cruiser is securely fastened, usually to a wharf.

"The running of the engines continues day and night, one side at a time. Any work that is required is attended to on the off days for each engine. This is

* An address to engineers of Cleveland.—*Marine Review.*

kept up until the wearing surfaces are well smoothed and the adjustment of valves has been perfected. During this time the boilers have all been used with forced draught, but only a part of them at a time. The blowers have been tested and all defects have been attended to. Air pressure, which is an important factor, has been watched very closely. The men have been properly drilled and taught to know and to do their respective parts. This usually requires about three or four weeks' time, and during that time it has been learned very nearly how much coal can be consumed to the square foot of grate and how many cubic feet of steam it will make, and also how much water can be evaporated. The best point of cut-off is established and the piston valves are altered to suit that when in full gear. This applies to the high pressure valves particularly.

"Having done so much, we may consider that it is now time to take the cruiser away for a preliminary trial. This is done to establish the pitch of the screws, and also to have all of the boilers at work at the same time with forced draught on and with the engines working at full power. This gives the men a chance to understand more fully all that is to be done when the official trial comes. After a short run the cruiser returns to the place where the docking is to be done, and is placed in dock. The bottom is cleaned and prepared for the trial and the screws receive proper attention. When this is over with, the ship is sometimes taken for another preliminary spin, and if the results are satisfactory, the contractor gives notice to the Secretary of the Navy that all is ready for trial. The trial board is then ordered to proceed to the proper place and go on with the trial as instructed by the Secretary of the Navy, a copy of whose instructions are sent to the contractor, informing him as to when and where the trial is to be made. A few days are usually allowed in which to get the cruiser ready. This getting ready consists in loading the ship to the proper draught specified in the contract, putting stores and men on board, coal in the bunkers, and a sufficient quantity of selected coal weighed and put into bags to make the trial. This coal is so placed that it can be conveniently got into the fires. The cruiser is then steamed to the harbor most convenient to the place of trial, and usually one day is aken in further preparation.

"We are now at our place ready for the orders to go on the trial in the morning. A consultation regarding plans of management is held between captain, pilot and chief engineer. Matters must be so arranged that all will move in perfect harmony. The time of starting and a signal to inform the engineer that the trial is finished are agreed upon between them only. With the representatives of the government aboard, the cruiser weighs anchor and with new fires and a low pressure of steam starts for the course, which it is preferable to have about one hour at half speed away. The start is made to reach the course at the appointed time, so that there shall be no delay. The forced draught is started as soon as cruiser is well under way, moderately at first. The firing is now kept up at very short intervals until the furnaces are well filled with fire. Nothing but the lump coal is used, and that is the best that can be obtained. When you consider that from 40 to 50 pounds of coal are consumed on a square foot of grate per hour, you will conclude that some work has to be done. It is simply driving to get all the steam you can, which means burn all the coal possible. But while this is going on it is necessary that there shall be no excitement. No loud talking can be allowed – all orders are given by signs or by the use of bells. The men have been thoroughly drilled and know what to do. In case of anything happening, and it is a matter that can be righted, it is done quickly. The men who have been selected for firing are at work with a will. The extra watch is employed to handle the dampers in the air ducts and to open and close the furnace doors. All has been timed so that about ten minutes before the first line of the starting point of the course is reached the cruiser is going at the top of her speed. Members of the trial board are at their respective stations. All of their arrangements have been made the day before, and since the start they have been getting their instruments in their places and at a signal from the deck the engineers begin their separate duties, noting steam pressure, vacuum, reading of revolution counters, revolutions of blowers, air pressure in air ducts, ash pans, uptakes; temperatures of steam, temperature of engine room, fire room, feed water, condensing water, speed of all auxiliary machinery, indicator, pumps both steam and water ends. This is done each fifteen minutes during the trial. The number of engineers for the government on these trials is from twelve to twenty. The steam must be kept steady and the fires burning. No cold air must be allowed to enter the furnace. It is kept out by keeping the blast on strong enough to fill the furnace with gas and flame. The boilers were filled with water as high as they could be with safety on the start. A tank of fresh water placed on the deck has a steam pipe leading into it, and a pipe to draw the water down into the feed water tank when required to replenish the boilers. The steam has been turned into the tank and the water heated to the boiling point. This water is wanted usually during the last hour. Then, too, the steam is wanted in the engines. If all has been rightly planned, and you can make the last of the four hours equal to the first, then you have done well.

"When the last hour is reached, all begin to count the minutes, and when the last line has been crossed every one down in the engine room is very much pleased, and in the fire room much more so if possible. If all has been carried out without a hitch or break, smiles are on all faces and congratulations are in order, but the reverse is the case in event of failure. As I have tried to show you that very much depends upon the thoroughness of preparation and the selection of the right men for these trials, in which a performance out of the usual course of engineering is expected, you will readily see that it would not be doing justice to the men engaged in the work to say that it is all play, but so far as I know all of those who go through it like it and will leave almost any place to repeat their experience."

A GENTLEMAN died suddenly in Paris, when it was found that his heart and liver and other organs were on the wrong side. He, however, lived to be eighty-five years old.

SOME ELECTRICAL PHENOMENA.

IN spite of the teaching of school boards and of the utterances of the practical man, there still remains a marvelous charm in the pursuit of that kind of knowledge often denominated useless. Possibly no knowledge is absolutely useless, but for the present many lines of research yield so small a harvest of results to which a commercial value can be assigned, that the gain they offer is infinitesimal compared with the labor they demand. As an example, we may quote astronomy. By the aid of its discoveries the mariner navigates the ocean and the explorer in foreign lands determines his positions. These are matters of great importance, certainly, but they are concerned only with the fringe of the subject. Years ago these operations could be performed with almost the same facility as to-day, and yet during that period many wonderful secrets have been wrested from the heavens. Much of the work has been done by men who followed other objects for a living, and who sought rest and recreation in intellectual problems of great complexity. Not only in astronomy, but also in other sciences and arts, are researches being continually carried on without thought or hope of reward. Men who spend laborious days in offices and works borrow hours from the night to engage in the pursuit of knowledge, finding it more absorbing than all the seductions of pleasure. In libraries whose volumes have been collected by painstaking care and some self-denial and in laboratories innocent of the glittering toys of the instrument maker, but filled with admirable home-made appliances, work is done that would fill volumes if properly recorded.

As an example of this class of investigators, we may cite Mr. James Wimshurst, whose name appears in every modern text book on static electricity. As many of our readers are aware, Mr. Wimshurst holds a prominent post in the consultative branch of the Marine Department of the Board of Trade, a position as far removed from electricity as can well be imagined. After days devoted to naval architecture, he seeks relaxation in other sciences, bringing to his subjects a wealth of ingenuity and handicraft skill which has made his workshop the resort of many of the leading scientific men of the day. Seldom a year passes that he does not evolve some brilliant experiment with which to dazzle the distinguished gatherings that assemble at Burlington House in May, each one being more beautiful than the last. For a long time he was unapproachable in his own province, but the lavish generosity with which he gave away the fruits of his experience has put into the hands of others the means to reproduce many of his effects. His influence machine marked an immense step in experimental research and furnished the means of generating static electricity at any time and in almost unlimited quantities. Before its introduction experiments with static charges could only be undertaken, "weather permitting," and generally failed before an audience. The labor and uncertainty attending them rendered them so difficult and laborious that they were not readily undertaken. Now the influence machine is as reliable as the common pump and responds to the first turn of the handle.

Hundreds, if not thousands of them, are in existence, scattered all over the world, and there is little prospect of their being superseded No one even thinks of attempting to improve them.

Mr. Wimshurst must have given away dozens of his machines, varying in size from the 7 ft. disks at South Kensington and the large multiple disk machine at the Royal Institution to little toys no larger than a crown piece. He is, further, always ready with advice and hints to other designers, even when they aim at surpassing his own efforts. In watching him perform his experiments, one gains the idea that they are absurdly easy and simple, but when the spectator endeavors to repeat them he soon finds that great skill and much experience are requisite for their accomplishment. Mr. Wimshurst's marvelous intuition in electrical matters is more misleading to the onlooker than the most carefully planned deception could be. Very slight variations of manipulation often make the difference between success and failure, and it has become second nature with him to choose the right course and avoid the wrong. It has ceased to be a matter of ratiocination, and is the unconscious expression of a thousand forgotten experiences which have moulded the action of his mind into singular conformity with the conditions under which he works. It is not that Mr. Wimshurst is not desirous that others should emulate his effects—on the contrary, no man is more devoid of jealousy or more anxious for the spread of knowledge—but that he is quite unable to realize how easy it is to go astray. We do not profess to explain in detail the mental process we are referring to, but it is one that most people are familiar with in art, if not in science.

A skillful pianist is unable to describe how his fingers thread their way among the notes and reproduce his improvisations, not only as regards the air, but also the harmonies; neither the actor nor the painter can reveal the secret of his art in its higher branches. All that can be written down and published in books is journeyman work; the action of the master mind is inscrutable.

We have seen experiments performed several times; sometimes in response to a chance request, and yet in less than five minutes the apparatus has been put together, and the operations have been in full swing, without a single word of explanation or apology for failure or shortcoming being necessary. We have also known able experimenters try to repeat them with their own apparatus, and find themselves in need of a second visit before even attaining a moderate degree of success.

One portion of a demonstration is most impressive. On a sheet of bronze paper there are placed two small Leyden jars, some 5 ft. or 6 ft. apart. Their insides are connected respectively to the positive and negative poles of a powerful Wimshurst influence machine, while their outsides are in contact with the paper, which is itself on an ordinary table not specially insulated. When the machine is worked, positive and negative charges are given to the two jars, while from the outsides flow charges of opposite name. As the table forms a very imperfect "earth," these latter charges get away with difficulty. The bronze paper, although looking very metallic, offers great resistance, as is shown by the sparks which traverse it. If the terminals of the machine are fairly close together, say 5 in. or 6 in. apart, the charge attains its full potential several times a second and discharges itself between these terminals. After each spark the outer charge on the jar has to get away, and it does so by throwing out brilliant green threads of flame in all directions. One could imagine that beneath the jar lay some fabled animal—a kind of tarantula—which, driven to bay, had taken refuge there and spat out burning venom in all directions. The energy and variety of the discharges are beyond description, and suggest, not the recurrent effect of a cause acting under constant conditions, but the fury and despair of a living being resolved to sell its life at the dearest price.

When the terminals of the generator are drawn wider apart, a fresh set of phenomena appears. The attraction between the charges in the two jars enables them to leap, or rather to skip, over the intervening 5 ft. This is not a clear jump through air, but a running passage over the feebly conducting paper, which offers, as it were, a series of stepping stones to bridge the wide space. At the same time the character of the discharge, both at the jars and the machine terminals, suddenly alters. It becomes brilliantly white, with a sudden snapping noise, the effect being trying both to the eyes and the ears. There is a thunderstorm in miniature, and not without some of its awe-inspiring effect.

The green radial lines, which still persist, but are almost lost in the fierce effulgence of the white discharges, have not impressed themselves on the photographic plate. The white sparks all seem to start from the jar connected to the positive pole of the machine —the left-hand jar—and to follow a devious course to the other jar, seeking the path of least resistance. Some of them turn in quite sharply at the last. It is a grand sight to watch the torrent of electricity leaping and skipping in its mad efforts to get from jar to jar, filling the room with light and noise and an overpowering smell of ozone.

Another is an example of a very different form that an electric discharge can take. Here the two terminals of the generator are faintly visible at each side, the positive (left) terminal being 2 in. in diameter and the negative 4¾ in. There is little evidence of the fierce disruptive energy depicted in the first experiment. It is true there is spitting—and very active spitting too—on the left side, but the sparks lose themselves in the palpitating violet haze that streams from the opposite terminal. The idea of energy is still impressed on the spectator, but it is of a different kind. Forceful and unceasing the brush pours across the intervening 14 in. to envelop and absorb the snapping sparks which seem powerless to make headway against its powerful stream. The effect is rendered more impressive by its silence.

Here we have another and very beautiful variety of electric discharge. Two tumblers 9 in. high by 4½ in. in diameter—goblets fit for Jupiter Tonans himself—serve as modified Leyden jars. On the inside they are coated with tinfoil to within 1 in. of the top, where there is a loose wooden cover dropped into each. On the outside there is a narrow strip of tinfoil at the base, the intervening space between its upper margin and the lip of the glass being coated with gum water in which a little bronze powder was mixed. The surface is thus rendered feebly conductive. The bases of the two tumblers are connected by a metal chain, which practically constitutes "earth." When the generator is rotated, these jars are charged until the potential exceeds the sparking distance between the terminals of the machine. But this distance represents a greater resistance than is offered by the bronzed surface of the glass, and hence the charge overflows every time.

From the inside coating a spark leaps from beneath the wooden cover, clears the inch or so of uncoated glass and then rushes down the outer surface. Seldom does it find the shortest way the easiest to follow. It comes over the edge of the tumbler vertically, but after that nothing further can be predicted as to its route. It may branch to right or left, or it may go straight. The one thing that it will not do is to follow the course of a predecessor. It must be remembered that these sparks occur singly and do not exercise any mutual repulsion. Yet they seem sedulously to avoid each others' paths; each one strikes out a line for itself, even if it have as its origin a point which has already seen the genesis of several preceding.

Quite a different result is gained if greater resistance is offered to the current. The jars are 16⅛ in. high, and the surface above the bottom band of tinfoil is coated with shellac, without the addition of bronze powder. There is no path along which the discharge can rush in an impetuous stream of well-defined course. It can only escape by filling every available channel and flowing in innumerable rills. These give the impression of beautiful vegetation, stretching upward in golden fronds that are ever reaching toward the summit, and falling back to again commence their momentary growth. The intricacy and delicacy of the pattern are marvelous, suggesting the frost tracery on a window, depicted in threads of fire. But if the potential be pushed too far, the energy of the discharge will overleap the full length of the jar and the 2 in. clear zone within it, and will produce a flash of intense brilliancy.

The effect of the added potential is great. The sinuous playful character of the upper discharge is replaced by one of painful vehemence. Not only does it leap the wide distance, but its effulgence spreads through the entire thickness of the glass, while along its course it throws out fierce vengeful sparks, seemingly purposeless in direction. The tree-like growth is drained of its energy to supply this violent flow and becomes almost invisible.

What is the practical value of these brillant phenomena? Frankly, we know of none. The true lover of science does not ask such a question. He finds his reward in mastering such a wayward, erratic force as electricity and causing it to display its activity in many and varied forms Every time he is able to evoke a new phenomenon his insight into the operation of nature is increased. His knowledge grows with each development, and the thirst for knowledge is an appetite that is increased by each attempt to appease it. Had it not been for this our race would still have been

enveloped in the obscurity of the dark ages, and we should have been shut up to material pursuits. The possessions which the world holds dearest are due to those who, in all times, have pursued useless knowledge.

The monks who copied the manuscripts of early times and so preserved them to posterity; the astrologers who observed the stars and left some record of their motions; the historians who collected traditions and legends; the painters and sculptors from whose works we learn the beauty of earlier peoples; all these followed pursuits of little or no practical value. Yet every atom of their work which has survived the ravages of time is immensely precious, and not only do its lessons become clearer, but it sheds light in unexpected ways on kindred subjects. So it is in science. Some day every fact will be found to have a niche in the great cosmos, and many that are now merely sources of intellectual pleasure will become of great material importance. Faraday's discoveries in electromagnetic induction were once regarded by the multitude as curious and strange, but of no practical value. Yet in comparatively few years there has been built upon them a new engineering industry, the result of which no one can venture to predict. The world is full of disconnected knowledge gathered without thought of reward by earnest students; but gradually the facts and partial theories are coalescing, and eventually will form an organized body that would be imperfect if any part were omitted.—*Engineering.*

ABOUT CASTOREUM.

OF all the sudden fluctuations in the market position of drugs which we have lately recorded, the rapid advance in the price of castoreum during the past two or three years has been one of the most remarkable. There are not many pharmacists who ever get an opportunity of seeing the drug, or whose knowledge of it, in the natural state, goes farther than the statements in the text books, which tell them that castoreum is the secretion contained in the castor glands of the *Castor Fiber*, forming a waxy substance of extremely

CANADIAN CASTOREUM PODS.

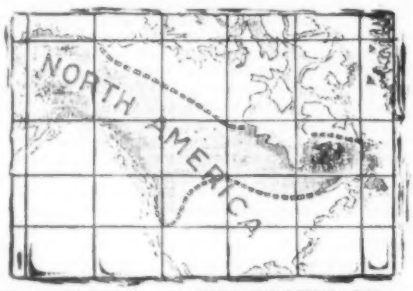
pungent odor, found in two large pockets placed near the base of the tail of the animal, enveloped in muscles specially fitted to enable the discharge of any portion at will, and which pockets are not connected with any other organ.

Piesse tells us that the odor of castoreum is developed in an extraordinary degree when the substance is infused in alcohol: 2 oz. of the drug in a gallon of spirit will make a standard extract, but if more than a quarter of a pint of the extract be added to a gallon of any other scent, the characteristic castoreum odor eclipses all the others.

At present the beaver is probably much more numerous in the Siberian than in the Canadian forest rivers, and he will probably survive in Asia long after his extermination on the American continent. But the habitable parts of Siberia are also gradually being brought under cultivation, and where the engineer and farmer penetrate, thence the beaver disappears. At present our market supply of castoreum still comes mainly from Canada. The Canadian article has risen in price tremendously during the last few years, and it now realizes nearly five times as much as in 1886.

Statistics show that the rise in price of castoreum has altogether outrun the dimensions warranted by the diminution of the supply, and from these circumstances it may be inferred that beaver hunting will receive fresh encouragement, and that—for a period, at any rate—castoreum will become once more sufficiently plentiful to allow of a considerable reduction in price. But it is not so certain that this will be the case, inasmuch as nearly the whole of the business is in the hands of one large trading concern, the Hudson's Bay Company, whose interest lies in the preservation of the high prices now ruling, and who will probably see to it that the market is fed sparingly. The company have long been in the habit of holding two auctions every year; the principal one about the middle of December and a smaller one in the spring. Most of the castoreum offered at these sales is bought for export to the Continent and India, for although, as our correspondence columns of the last few weeks have shown, the drug is still occasionally prescribed in this country, the consumption here is of no account compared to that in France, as an ingredient in perfume manufacture, and in other countries as a medicine.

Singularly enough the price of Siberian castoreum has declined almost in the same proportion as that of the Canadian article has risen. About twenty-five years ago Siberian castoreum, then of extreme scarcity, is said to have realized as much as £22 per lb. in the European markets; in 1891 it might be had for a tenth of that price; but since then it has again doubled in value. It was formerly official in the German Pharmacopœia. In 1878 and 1879 castoreum from beavers



DISTRIBUTION OF THE BEAVER IN 1850.

caught in the Elbe and other German rivers was still offered in the market. The quality, however, was not much liked, and the drug does not appear to have been offered in quantities of sufficient importance to make it a commercial article. In value it ranged about midway between Canadian and Siberian castoreum.

A representative of *The Chemist and Druggist*, anxious to find out something about that part of the trade in castoreum which ends with the selling of the drug at the London auctions, called for that purpose upon Mr. W. Halsey, the Hudson's Bay Company's broker, at the old house of the company in Lime Street.

Mr. Halsey was busily engaged sorting skins, still, as ever, the principal article of trade of this company. During the winter time every minute of daylight is valuable to a skin valuer, for the goods cannot be properly judged by artificial light, and the aggregate yield of a Hudson's Bay sale runs into thousands of pounds. On January 15, for instance, Mr. Halsey's auction catalogue included 46,412 beaver, 648,687 musquash, and 58,154 American rabbit skins, not to mention 11,799 salted and 353 dressed fur seal hides.

"Now, sir," said Mr. Halsey, when the gray twilight began to descend upon Lime Street and soften the severe contours of its brick walls, "I am at your disposal." And with that he divested himself of his cotton overalls and turned up a book of prices realized at auctions. "You want to know about castoreum, isn't it?"

Our representative assented, and thinking that he might as well go to the heart of the matter at once, asked: "Where do you get your supplies from at the present time?"

"Well," said Mr. Halsey, "I don't know that it would be wise to answer that question right off. As you probably know, our castoreum bears different marks, which roughly indicate the districts it comes from. Thus YF stands for Fort York, here, about halfway up the west coast of Hudson's Bay. All the castoreum that comes in from the region north of Canada proper and east of the Rockies is brought into trade by way of Fort York." And Mr. Halsey's hand covered a district on the map measuring so many hundreds of thousands of square miles that any fear of a competitor acquiring valuable information from the Fort York tip may be dismissed as groundless. "Then there is MR (Moose River, a fort of ours at the mouth of the river of the same name, at the southernmost end of the bay). Castoreum so marked comes mostly from the Moose River district—partly also from Western Canada. The 'Canada' mark indicates the produce of Eastern or Lower Canada, and by N.W. (northwest) we understand everything produced west of the Rocky Mountains. These are the four great geographical divisions of the drug."

"As to prices?"

"The price has risen enormously lately, as you know, and I am convinced that the rapid diminution of the supply is a partial explanation of that fact. The beaver's days are numbered. He cannot co-exist with civilization. Until the last few years we imported 100,000 skins a year on an average. This year we have barely received 60,000, and the prospects for the future are still worse. Our castoreum auctions, too, have declined from an average of about 2,500 lb. per annum about ten years ago to barely 1,300 lb. now."

"Then you look forward to the time when a castoreum pod will be as scarce as a great auk's egg?"

"I am afraid that will be the end of it. The beaver

THE HUDSON'S BAY COMPANY'S BEAVER TOKEN.

cannot be domesticated. All attempts to rear him in captivity have failed."

"Your last small December sale does not represent the whole quantity you intend to offer this season, I presume?"

"We shall have a small sale of N.W. castoreum in March or April, but it will not exceed a few hundred pounds. It takes some time longer for this brand to reach here than it does for the others. As the bulk of our castoreum is here in December, we always have a sale in that month, and what little comes afterward is sold in the spring or early summer. At one time our company were the only importers of castoreum," said Mr. Halsey, "but now there are others in the field. One firm import from the United States, and I believe that some castoreum also comes from Alaska. It is cured quite differently to ours."

"I should like to hear something about the preparation of the drug."

"I regret I cannot enlighten you about that," came the answer. "The Indians who trap the beaver bring the skins and castor pods to our forts and exchange them for provisions and clothing. They are very clever at adulterating the pods, filling them with rubbish, and closing them up again so that it is difficult to detect the fraud, and our officers require to be very careful. The castoreum is generally somewhat wet when it arrives here, and it is graded into 'firsts,' 'seconds,' 'thirds,' and 'pickings,' according to its quality. When skins were more plentiful than they are now, and castoreum was worth only about 15s. per lb. or so, we thought very little of it as a branch of our trade, but nowadays it is an item of fair importance in our business.

"See here," continued Mr. Halsey, turning over the pages of his salesbooks. "The lowest price on record is 7s. per lb., and from 1881 onward the average price of our consignments has steadily risen from 21s. up to 104s. per lb., and the quantity offered for sale has diminished by one-half."

"But if you ground your reason for an advance entirely upon the increasing scarcity of the drug, how do you explain that the value has multiplied by five while the supply has only fallen off one-half?"

"Probably the use of castoreum in medicine is increasing, and the substance is one of those, you must remember, for which there is no substitute. To the medical man or perfumer the price is a matter of secondary importance."

With this our representative took his leave, to devote himself to the historical side of this interesting subject.

In 1536, when Jacques Cartier, the first European who trod Canadian soil, landed upon the shore of the St. Lawrence River, the beaver was distributed over a larger area than any other animal in North America. Its habitat ranged from the Mexican Gulf to the Arctic Ocean and from Alaska to Florida. On vast tracks of prairie land, within these boundaries, it was, of course, unknown, but along the great rivers the rodent overran the country. It was hunted by the Indians chiefly for the sake of its fur, its flesh, its castoreum and the supposed curative properties of its fat, but the natural increase of the animal must have

THE BEAVER AT HOME.

greatly exceeded the numbers slain to furnish raiment to the redskin.

With the advent of the white man the beaver's period of tribulation commenced. To the unsophisticated mind of the redskin a piece of scarlet cloth, a string of beads or a musket was a possession acquired absurdly cheap at the cost of many beaver skins, and beaver hunting at once became a profession, followed with all the enthusiasm that the hope of acquiring some of the white man's trinkets could inspire. The medicinal virtues of castoreum and other parts of the animal soon became famous in Europe, although a century and a half, in the course of which many millions of beavers had been sacrificed upon the altar of commerce, elapsed between the discovery of Canada and the publication of the first European treatise devoted to the medicinal virtues of castoreum. That treatise, published in the year 1685, was the work of one Joannes Franco. It bore the following lengthy explanatory title: "'Castorologia,' explicans castoris animalis naturam et usum medico-chemicum, antidhæ (?) à Joanne Mario, Bollensi et Physico Ulmano postea augustano celeberrimo labori insolito subjecta. Jam vero ejusdem auctoris et aliorum Medicorum observationibus luculentis ineditis, adfectibus omissis, et propria experientia parili labore aucta à Joanne Franco."

According to the author there were few parts of the beaver that were not medicinally valuable. Indeed, he avers that the beaver was hunted for "its skin, its fat, its blood, its hair, its teeth, and especially for its pockets or tumors, which are placed in the groins." The skin is alleged to cure bed sores and consumption in children, and to be eminently useful in "colic, madness and spasms." The beaver fat is an excellent cure for affection of the nerves, epilepsy, apoplexy, toothache, asthma, dysentery and strains. The blood was also given as a remedy for epilepsy, the hair was recommended as a styptic. Beaver teeth tied round the necks of infants were esteemed excellent in promoting the cutting of the teeth; powdered, they were given in soup to epileptic children. The author of the treatise mentions a number of cures effected by him in cases of sciatica, "loss of memory," pleurisy, and so on.

"The doctors of Augsburg," continues this writer, "have introduced castoreum into thirty of the best compositions of the Pharmacopœia. It destroys fleas; is an excellent stomachic, stops hiccough, induces sleep,

strengthens the sight, is used as an antidote to the sting of scorpions, spiders and the tarantula, the bad effects of opium (*sic*), and even against the pestilence." In this style the learned author meanders on through pretty nearly all the complaints known to the faculty, winding up with a eulogy of the drug as a "proved remedy for earache, and not less efficacious in deafness."

Probably castoreum was low in price at the time. There is no particular reason why it should have been otherwise, for hunting went on merrily (from the huntsman's point of view) all through the seventeenth and eighteenth centuries. We have no means of tracing the market value of the drug when "Castorologia" was issued, but in the price list of 1756, which we reproduced in *fac-simile* some years ago, we find "Castor, Hudson's Bay," quoted at from 8*s.* to 9*s.* 6*d.*, "Castor, New England," at from 7*s.* to 7*s.* 6*d.*, and "Castor, Russia," at 36*s.* per lb. It is curious to observe how from the earliest times on record until quite recently, Russian and Siberian castoreum has been held in higher esteem than the American drug.

But let us return for a moment to the history of the persecution and extermination of the beaver. Ten years before Jacques Cartier descended upon Canada, the beaver breathed his last in the British Isles, but so late as 1714, when the Canadian beaver skin trade had been in full swing for generations, numerous colonies of the European beaver were still found along the River Elbe, where they were protected from extermination by law. The first Canadian fur-trading post was established in 1604, and from that time onward until within the memory of the present generation the unfortunate rodent was the prop of British North American trade.

Attacked from the North by the agents of the "Company of Adventurers Trading into Hudson's Bay," by the Dutch, and later on the British, from the New England side, by the French from the St. Lawrence, and by the Indians from all parts, the beaver quickly disappeared from all its haunts accessible to man.

In 1733 the Hudson's Bay Company exported annually about 15,000 beaver coats and 175,000 skins, while the French company of Canada, in 1715, sent to Europe about 100,000 skins, and 80,000 more came into trade *via* New York. Beaver skins were the standard of value of all goods traded with the Indians, and from an "Account of the Countries Adjoining to Hudson's Bay," published in 1774 by Arthur Dobbs, we find that in that time three marten skins, one wolf skin, or 1 lb. of castoreum were reckoned as the equivalent of one beaver skin. On the other hand, the Indian had his choice, from among other commodities, of one dozen needles, one checked shirt, 1½ lb. of gunpowder, or a dozen buttons in return for such skin. In such trading matters, the "giving too little and asking too much" was not confined to one particular European nation.

In 1821 the Northwest Company of Canada was incorporated into the Hudson's Bay Company, and shortly afterward measures were devised for putting an end to the reckless extermination of the beaver. A still greater piece of luck befell the wretched animal a few years later, when the adoption of silk to the hat-making industry sealed the doom of the heavy beaver hat, which had flourished so long as the Moloch to which millions of the rodents had been sacrificed. But for this invention the beaver would now probably have been as extinct as the bison, for early in the century matters were already rapidly tending that way. In 1814, as far in the interior as the Mackenzie River, the Indians complained of the want of beaver, and presently all the posts in that district were closed for that reason alone. Immediately after the rise of the silk hat, however, the beaver began to show a noticeable increase in many parts of Canada, and for many years, in fact, until well into the sixties, it must have seemed to the animal as if the old Indian days were returning. Railways and immigration, however, have since had their effect upon the beaver and elbowed it out of all the cultivated districts.

The map here reproduced, which is taken, with our other illustrations, from another book called "Castorologia," published a couple of years ago, shows the distribution of the beaver about the year 1850. According to it, the animal at that time had disappeared south of the St. Lawrence and had lost its hold upon the United States, all but a small section in the extreme Northwest. Major W. Ross King, in his book "The Sportsman and Naturalist in Canada," states that "at the present time (1866) the beaver is found on lagoons and streams in the country about Lake Superior and the Roseau River. Eastward it is tolerably plentiful on many of the small tributaries of the Restigouche, and in the more remote regions of British North America is abundant;" and Mr. Horace T. Martin, a Canadian author, writing in 1892, observes: "Some colonies still linger in the United States, on the slopes of the Rocky Mountains, and are sparsely scattered over the continent; but along the watershed between the Hudson's Bay and the St. Lawrence, in the upper waters of the Frazer and Peace Rivers, and along the (Canadian) Rocky Mountain range may be considered the last homes of the beaver."

The possession of castoreum pouches has been a fatal gift to the beaver. Until the end of the last century the Indians were restricted to few and comparatively clumsy methods in hunting the animal, but at that time the natives of New Brunswick and of certain portions of Canada, observing the success of the white man in catching fur-bearing animals with a steel trap, turned their attention to the possibility of adopting this means to augment their store of beaver skins. The one difficulty in the way was that no bait was known sufficiently attractive to allure the beaver to it in preference to the vegetable foods in its haunts [it lives mainly upon the rhizome of the large yellow pond lily (*Nuphar luteum*)]. Mixtures of various drugs, foods and herbs were tried in vain for a long time, until at last some one hit upon the idea of baiting a trap with castoreum, the beaver's own secretion. The effect was marvelous. The beavers rushed to the castoreum baited traps, like Indians to whisky, as if impelled by an irresistible force. As Mr. David Thompson, a careful observer of life in the Canadian backwoods at the end of the last century, puts it, "the secret of the bait was soon spread. Every Indian procured from the trader from four to six steel traps (weighing from 6 to 8 lb. each), and all labor was at an end: the hunter moved about at pleasure with his traps and infallible castor bait." Mr. Thompson saw several instances of the infatuation of the beaver for castoreum.

Sometimes beavers escaped from castor-baited traps with the loss of limb, but they would invariably return to their doom within a couple of nights. The castoreum stick was always licked clean, and the substance seemed to act upon the animal like a soporific. When the Nepissing, Algonquin and Iroquois Indians had exhausted their own districts they followed the retreating beaver northward and westward. For a while the Indians reveled in gin, beads and scarlet cloth, and the traders' canoes carried such loads marketward that beaver products became almost unsalable in the London market. But within four years of the introduction of castor bait the whole country of the three tribes mentioned was beaverless, and the Indians fell into a state of helpless poverty. The profits to the white trader on the sale of beaver skins at the commencement of that period are said to have averaged 2,000 per cent.

The castor trap has never been superseded, and to this day every trapper carries among the impedimenta of his craft a bottle of "medicine," consisting of a vegetable extract of some kind flavored with castoreum. The castor used for trapping is not smoked and cured like that seen in the London market, but consists of the fresh, oily substance. It is also employed now for trapping lynxes and other valuable fur-bearing animals, for which the secretion possesses a fascination second only to that which it exercises upon its own producer.

Among the Indians castoreum has been held in therapeutic repute from time immemorial, and they also use it to flavor the bark mixture which they are in the habit of smoking when tobacco is scarce.

The Hudson's Bay Company are now doing all in their power to prevent the total extermination of the beaver. They have systematically set aside certain islands, particularly favored by the animals, along the coast of Hudson's Bay, as beaver reserves. These islands are visited every third year (which is the period in which a beaver kitten matures), when as many animals are killed as are calculated to represent the natural increase during that period. But within a few years the beavers will have destroyed all the trees in the islands, and then, unless new preserves are started, the animal will probably be within measurable distance of extermination. Proposals for the establishment of beaver ranches, however, are constantly being mooted in the Canadian press. In certain parts of the Canadian Rockies, where colonization is now taking place, the beaver colonies are said to be protected expressly in order to preserve the water supply, for experience has shown that in many parts of British America the extermination of the beaver has been followed quickly by severe droughts.

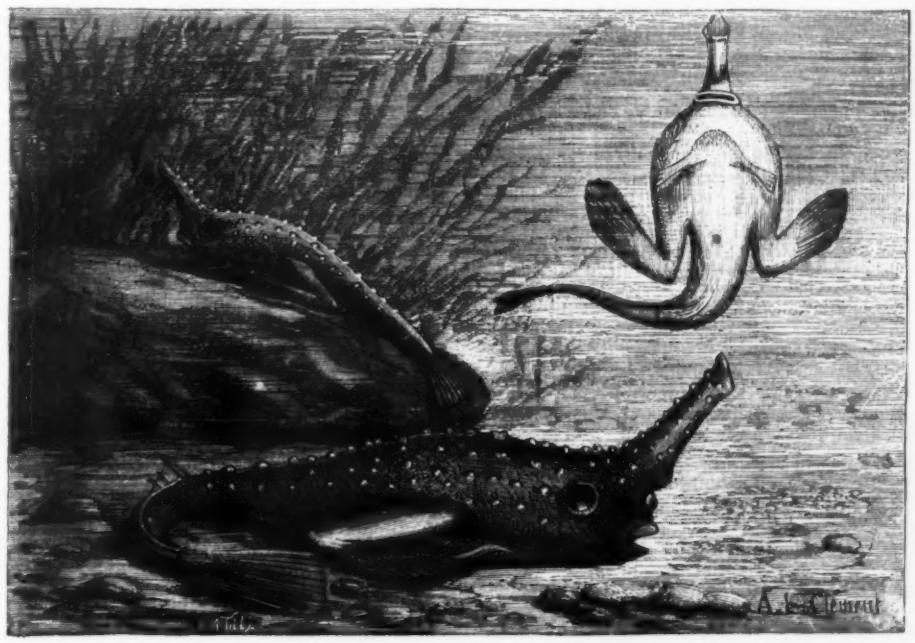
The beaver is the national emblem of Canada. It appears upon the arms of that country from the times of its first settlement. Its name survives in scores of Canadian rivers, settlements and miscellaneous landmarks. It has a place, as philatelists well know, in the postage stamps of the Dominion. "Beaver tokens" were issued at one time by the Hudson's Bay and Canadian Northwest Companies as tallies for skins bartered from the Indians. They are now among the rarest of numismatic curiosities. That which we here reproduce in *fac-simile* was struck in 1854 or 1855 at the suggestion of Mr. McTavish, then in charge of the Albany Fort of the company. It bears the coat of arms of that corporation: a shield quartered, with a beaver in each quarter, a fox for the crest, two stags as supporters, and the motto, "Pro Pelle Cutem" ("The skin for the fur"). The legend on the reverse consists of the initials of the company, and letters E. M. for East Main, the district in which the tokens circulated. The "½" stands for the value = half a beaver skin; there were also eighths, quarters and full units, and the N. B. is a mistake for MB = "made beaver," signifying the flawless skin of an adult specimen. The last of *Castor Canadensis* has long gone to Great Manitou's happy hunting grounds, and he has been followed in due course by the last of the bisons. And as a companion of these great figures in the story of the North there will appear, at no very distant date, the ghost of the last of the wild beavers.

THE WALKING FISH.

FISH, as every one knows, have their organs adapted for swimming, so that they exhibit arrangements very unfavorable for any other kind of locomotion. However, a few most interesting exceptions are observed. Certain types find themselves forced, either by surrounding circumstances or for seeking food, to leave the water for a certain length of time. Thus the flying fish is adapted both for flying and swimming, and there are others that are truly walkers. We may mention the *Maltha*, a Brazilian fish, which most certainly attains the highest degree of differentiation in this direction. We have had a specimen of it in our hands which came from Bahia, and we profit by it to call attention to the most curious peculiarities that it exhibits. In the accompanying engraving one of the figures gives a view of the ventral side and the other a profile view, both reduced about one-third.

It is a fish which cannot swim, but is forced by its very organization to walk, or, perhaps, to hop after the manner of toads, of which it has vaguely the external form. The head, which is very large, is provided at its anterior part with a bony spine, at the base of which are situated the nasal apertures. The bronchial orifices are small apertures situated wholly in the dorsal surface, as in the Callionymes, so that the water can remain for a long time in the bronchial chambers—a circumstance very favorable for species so frequently at a distance from water. The entire body, save the ventral wall and the tail, is covered with bony plates forming a very ornamental cuirass. Behind the hind members the body tapers considerably, so as to resemble a tail terminating in a fleshy fin. Upon the dorsal crest there are observed three or four little spines, the remains of the dorsal fin.

The locomotive organs exhibit truly interesting arrangements. The anterior (the pectoral fins), which are quite small, and are situated under the belly, have truly the form of small thin paws terminating in a widened fleshy portion not at all palmate. Here we have already well modified fins; they are no longer capable of acting on the water, and must perform nothing but backward and forward motions. But the posterior organs (the ventral fins) are still further transformed. They stand out laterally, and first turn downward and then bend upward and outwardly, forming a true articulation. They terminate in a wide and fleshy paddle.



THE WALKING FISH (*Maltha vespertilio*).

These are very different from the same fins in other fishes. We have here the formation of a true limb, that naturally cannot serve for swimming, but only for walking, after the manner of toads, which move scarcely anything but the foot and leg, the thigh remaining closely applied to the body and nearly motionless.

Finally, one peculiarity which well shows that the animal is destined for crawling is the form of the anal fin, which, instead of being protuberant and flattened laterally, is here adherent to the tail and flattened vertically, so as to resemble a small elongated and concave blade. This is, we believe, one of the rare examples of the adaptation of the anal fin.

We may clearly see that all the arrangements conspire to the same end, *i. e.*, to prepare organs primitively adapted to swimming for a very different function. The differentiation does not attain a very high degree, but it is clearly indicated. It would be very interesting to examine these paws from the standpoint of osteology. Perhaps a new fact might be added to that so much discussed question of the homology of the organs of fishes with those of the higher vertebrates.—*La Nature.*

NOTES ON FISHES.

IN Florida, there are numbers of ponds all isolated from each other, and varying greatly in size. These ponds may be mere hollows, without any perceptible source of water supply. Others, again, are placed at high levels—a fact which removes any idea of their owing their existence to overflows or floods from other sources. Now, all these Floridan ponds swarm with fishes, and the question arises, whence do they derive their living tenants? In the warm season the smaller ponds become dried up; yet on being refilled, from whatever source, their fish tenants appear to be as plentiful as before. In one case a pond situated at a

very high elevation contained an abundant fish population. A writer tells us he has twice noticed this pond to be dried up; yet, after refilling, its fishes were as numerous as of yore. Perhaps the explanation may be found to rest on the fact of the fishes having acquired a power of resisting dryness of their surroundings. The mud fishes (*lepidosiren*) are able to live packed in dry mud; but then they possess lungs in addition to gills, and are thus direct air breathers during the dry season. The Florida fish ponds would appear at least to offer a very interesting problem for local zoologists, and one may hope to hear of a solution of the facts being forthcoming at no distant date.

The case of the Florida fishes reminds me that in 1803 Von Humboldt saw a volcanic eruption at Cotopaxi, in the Northern Andes. From the crater were ejected large numbers of fishes. Humboldt's observations were received with surprise and incredulity; but they have been fully confirmed by later observers. In other volcanic peaks of the Andes range the ejection of fishes has been observed. They have been thrown to a height of 16,000 feet above the sea level, and half that height above the plains below the mountains. The species of fish has been named the *Argas Cyclopum*, and it appears to be the only kind which is ejected from the craters. The fishes appear occasionally to be thrown out in such numbers that the decay of their bodies produces noisome exhalations in the adjacent territory. The clew to this mystery may be found, perchance, in the fact that the Argas fish live in lakes in the vicinity of the volcanoes. Now, as volcanic eruptions are associated with water, and as that water, gaining admittance to the earth's heated interior, is converted into steam—a volcanic eruption being merely a kind of cosmical steam explosion—it does not seem at all improbable that the fishes are swept into the line of volcanic action from the lakes, and simply expelled, after a hurried subterranean journey, from the volcanic crater. If this speculation should prove to be correct, it will only tend to show, once again, that truth is stranger than fiction. We have heard a good deal of late years in novels about mystic subterranean journeys and underground expeditions; and our fishes may lay claim, perchance, to all the distinction which attaches to such marvelous explorations.

The fecundity of fishes is proverbial. The latest account I have seen of this property of the finny tribes is that of the number of eggs in an eel weighing six pounds, which is set down at nine millions. I fancy the cod and herring are not far behind the eel in respect of their fertility. Nature is ever prolific, but is sadly handicapped by the tremendous waste of her materials which everywhere occurs. Thousands and thousands of fish eggs come to nothing, of course. Many are devoured; still more are simply killed by cold. Little wonder, however, that naturalists should calculate that unchecked development of such a host of eggs as the eel possesses would in a few years fill every ocean with a solid mass of fishes.—*Andrew Wilson, in Illustrated London News.*

THE DEVELOPMENT OF THE CHICK.*

CHARLES BONNET, the distinguished naturalist, was born in Geneva in 1720 and died in 1793. He worked assiduously with microscope and lens and devised many new experiments on plants and animals. He was a friend of Haller's and stoutly maintained the latter's doctrine that all the vital functions could be reduced to two—sensibility and irritability. His first important work was the investigation of the life history of aphides, and his interpretation of parthenogenesis was a great triumph to the *ovists*. The process of development in his time was considered by many to be purely a process of unfolding of a preformed germ which contained in miniature the future animal or plant. But the supporters of his idea were divided into two camps; the *animalculists* held that the miniature animal—the germ—was carried in the male seminal fluid to the proper matrix, where it found suitable nourishment and grew—*i. e.*, unfolded. The *ovists*, on the other hand, maintained that the germ existed in female, and explained fecundation as a stimulus produced by the male fluid, which furnished the first nourishment of the tiny germ. The fact, then, that a female aphide could produce offspring without coupling with a male seemed to give the ovists a convincing argument.

His works are interesting reading to-day, for he was not only a keen observer but a careful writer as well. To be sure his facts are often meager, and often the results of his or his contemporaries' observations were insufficient to base the broad generalities upon in which he delighted; yet within the knowledge that he had he argued well. Who knows but what the student of a hundred years hence may smile at Weissman's conclusions as we do at Bonnet's? In the following description of the development of the chick the reader should always keep this in mind and should as far as possible forget for the time much of the detail that has become known to us since improved microscopes and sections have been in use. The selection translated below may be found in his "Contemplation de la Nature" (tome iv., pt. 1, chap. x.), published in 1764:

LA GENERATION—LE POULET.

An egg not fecund has a yolk like an unfecund egg. The goodwives have known this all the time; and there is in this little fact, so well known, so little examined and so worthy of it, something which comes to throw a flood of light and has cleared away the shadows with which the great mystery of generation has been enveloped.

Give all your attention to this: you are going to put your finger on an important verity. A membrane invests the yolk internally, and this membrane, which is only the continuation of that which covers the small intestine of the chick, is common to the stomach, the pharynx, the mouth, to the skin and epidermis. Another membrane invests the yolk externally, and this membrane is only the continuation of that which covers the intestine; this unites with the mesentery and peritoneum. The arteries and veins which course through the yolk derive their origin from the mesenteric arteries and veins of the embryo. The blood which circulates in the yolk receives from the heart the impulse of its motion.

The yolk is, then, essentially, an appendage of the intestine of the embryo, and together they form an organic whole. Therefore, in earliest times, the chick is, to some degree, an animal with two bodies: the head, trunk and the extremities compose one of these bodies; the intestines and the yolk form the other. At the end of incubation the second body is pushed within the first, and the two make but the one.

But since the yolk exists in eggs which have not been fecundated, it follows necessarily that the germ is preexistent to fecundation. This consequence stares one in the eyes: you come to see that the yolk is an essential part of the chick. You recognize the direct connection between the one and the other. The chick has not existed, then, without it. The membranes and vessels of it are only a continuation of those of itself. And how many other things there are which they have in common, which prove that they have never existed separately. The chick was, then, entirely in the egg before the fecundation. Then it owes not its origin to the liquor which the cock furnishes: it was defined *en petite* in the egg, prior to the commerce of the sexes. The germ, therefore, pertains exclusively to the female.

The evolution or development proceeds by nutrition; you have seen it. Nutrition supposes circulation; you have seen it also. Finally you have seen that the heart is the seat of circulation. If it does make a circulation in the germ before fecundation, you will admit at least that it is not sufficient to perform the whole evolution which will render the germ visible, and which gives to all its parts the form, proportions, and arrangements which characterize the species.

The germ cannot achieve its development in an egg which has not been fecundated, and incubation will only hasten its corruption. Yet what does it lack in order to continue to grow? It has all the organs necessary to evolution. It has taken on itself a certain increase, for eggs increase in virgin pullets; their ovaries contain them in various sizes. The germ may grow, then. Why can it not develop completely? What secret force holds it back in the limits of invisibility?

Growth depends upon the impulse of the heart. A great growth depends upon a great impulse. The heart of the germ which is not fecundated lacks this impulse.

This demonstrates a certain resistance in the parts of the germ. In measure as it grows, this resistance increases. Some parts resist more than others; the osseous parts more than the membraneous.

The heart of the germ, then, needs a force proportioned to overcome this resistance. Its force is in its *irritability*, or in the power to contract when brought into contact with a liquid. Augment this irritability, and you augment its impulsive force.

Fecundation increases, without doubt, this force, and it alone can do that: since it is only by its intervention that the germ succeeds in freeing itself from the narrow limits which restrained it in its first stage.

The fecundating liquor is, then, a true stimulant, which, carried to the heart of the germ, excites it powerfully and communicates to it a new activity. This is what we call *conception*. Movement once impressed on this little prime mover is conserved by the unique energy of its admirable mechanism.

But it does not suffice that the heart acquire a force capable of overcoming the resistance of solids: the fluid which it sends them for nourishment must be proportioned to the marvelous fineness of the vessels. A blood such as ours would not circulate. The blood of the embryo at first is a whitish liquid; it turns yellow by degrees and finally becomes red. The impulse of the heart dilates the vessels more, and they admit larger particles, heterogeneous and colored.

The generative liquor is not, therefore, a simple stimulant: it is besides a nourishing fluid, appropriate to the extreme delicacy of the parts of the germ. It fulfilled already in the body of the fertilizing individual the functions of a nutritive fluid: it made the comb and spurs grow and gave strength to all parts. You recall the degeneracy of the capon, and how it differs from the cock. You might have many more proofs that the generating fluid is the first aliment of the germ.

Transported by the arteries to all the parts, it unites with them in a fixed manner, according to the proper nature of each. The chick is not slow to lose its form of tadpole. Wings, legs and feet proceed out of the long tail; everything comes out, fashions itself and arranges itself on a new model. The little animal, stretched out at first in an almost straight line, curves itself more and more. It invests itself more and more with muscles, tendons, bones and feathers, and in 18 or 20 days it is a perfect chick. B.

* From *Science*.

THE DYNAMICS OF THE ATMOSPHERE.

UNDER this title a series of articles appeared in the *Meteorologische Zeitschrift* for May, August, and September, 1893, from the pen of Prof. M. Moller, of Brunswick, which treat of many of the important processes that are at work in our atmosphere. The following review is made by *Nature*.

The principal feature in these discussions is that the author treats the various phenomena as the result of complicated processes, and inquires into their character separately, prior to attempting to draw conclusions from them, so that some relations are presented in a new form.

With regard to the part which aqueous vapor plays in the atmosphere, it is usually stated that the heat set free in condensation during the formation of clouds greatly favors the origin of ascending air currents, but Moller takes another view of the matter. Two columns of air have usually been compared with each other, having at their base similar initial temperature, but in which the decrease of temperature with height proceeds in a different manner, as one column is supposed to contain dry air that is very cold at the upper end and the other moist air warmed by condensation. But the author considers that this difference of temperature does not actually occur in this manner, and that all theories based upon this assumption must lead to erroneous results. He states that as the air of the upper strata has risen up previously, it has consequently gone through the process of warming by condensation, so that the increase of heat caused by condensation cannot produce by itself a higher temperature in the ascending current than that possessed by the surrounding air; hence the cause of the upward impulse, which has been attributed to the aqueous vapor of the air, disappears. If it is wished to produce a circulation of the air in two vertical tubes in communication at both ends, the air in the bottom part of the one tube must be warmed, while that in the upper part of the other tube is cooled; but if the source of heat is applied at the top, a condition of stable equilibrium and rest takes place. In the same way the condensation of the aqueous vapor causes a warming of the upper strata of air, the effect of which is generally to produce a condition of stable equilibrium, contrary to the theory which assumes that the condensation of the vapor favors the ascending current, and consequently gives rise to depressions. The author attributes the chief cause of the origin of cyclones to horizontal differences of temperature in the earth's atmosphere, to the steep gradients of the upper strata caused by them, and the consequent strong movements of the air in those regions. He agrees in the main with the views of Ferrel, but attributes greater importance to the effect of friction against the rough surface of the earth. The air which rises at the equator, and moves in the upper regions toward the pole, takes, according to the law of the preservation of the moments of rotation, a west to east velocity, whose right-handed deflective force in the northern hemisphere is opposed to the poleward motive effect of the upper gradient.

According to Prof. Moller, this right-handed force over the dry zone, in the belts of high pressure, on both sides of the tropics, and in higher latitudes, becomes so great that a condition of equilibrium of the forces is produced in the direction of the meridians. Apart from local disturbances, the upper wind here follows the parallels of latitude, unless owing to friction, or the mixing of the upper and lower strata, a diminution of the upper current occurs, whereby the meridianal deflecting force of the upper gradients gains the mastery over the decreased right-handed deflective force arising from the centrifugal effect. Only then, and in proportion as this diminution of the upper current occurs, does the upper current follow the meridianal upper gradient. In this case a part of the energy gained in the upper currents of the atmosphere is transferred to the lower strata, so that there the velocities which are directed from west to east increase. The atmosphere, therefore, in the temperate and polar zones, is like a caloric machine, which first produces by meridianal gradients of temperature the upper gradients of pressure, and consequently an air current from west to east at a great height, whose transference to the lower strata of air depends upon opportunities of friction or mixture of masses of air. The meridianal advance of air in the upper air current is checked by the centrifugal force; for the advance to the pole increases the velocity of the west wind, and thus the centrifugal right-handed deflective force whose effect stops the meridianal advance of air to the pole. Moller states that this important relation of interchange was not clearly expressed in Ferrel's theory. He first assumes that a circulation between the hot and cold zones takes place unhindered, and, provided the circulation takes place, he makes the high velocities to exist in the upper current. Ferrel also computes the great forces which would be necessary in order to produce those high velocities, and he admits that these really do not exist. He speaks of this theory as only approximately correct, whereas the computed forces and great meridianal differences of pressure fail in nature, and the high westerly wind velocities, such as his theory requires, do not exist.

Prof. Moller concludes (1) that the regular and undisturbed circulation of the atmosphere between the hot and cold zones is not accomplished in the manner hitherto supposed, and as has been presumed in Ferrel's calculations, and states that if Ferrel's theory is to become of practical use, it will be necessary to study more exactly the relations between the friction of air on the surface of the earth, and especially the friction or the mixture of air between upper and lower strata. (2) If friction of air against the earth's surface is great, the velocity of the winds is less; but if friction, or mixture of air, between upper and lower strata is great, then the lower winds blow more violently. (3) In higher latitudes no storm can be caused by horizontal meridianal gradients of temperature without mixture or friction between the upper and lower strata.

SUPPOSED EVIDENCES OF A POST-GLACIAL SUBMERGENCE IN EUROPE.*

By Prof. G. FREDERIC WRIGHT, D.D.

THE theory of an extensive post-glacial "submergence of Western Europe and of the Mediterranean coasts, at the close of the glacial or so-called post-glacial period and immediately preceding the neolithic or recent period," has recently received the high indorsement of Prof. Joseph Prestwich, lately retired from the chair of geology at Oxford, England. Prof. Prestwich's discussions of the subject have mainly appeared within the year past in two lengthy papers, prepared with his accustomed careful attention to all details. One paper with the above title is published in the "Philosophical Transactions of the Royal Society of London," Vol. 184 (1893), pp. 903-986. This deals with the evidence upon the Continent. The other paper appeared in the "Quarterly Journal of the Geological Society of London" for May, 1892, Vol. 48, pp. 262-343, and treats of the evidence in Southern England. The facts upon which Prof. Prestwich bases his inferences are those relating to the so-called "rubble drift," raised beaches and fissures filled with the bones of recent extinct animals. All these phenomena appear in Southern England, Northern France, and around the shores of the Mediterranean to Syria.

The rubble drift is something like the ordinary talus found at the foot of precipices and hills, only it is distributed further from the base than is possible if it were due to ordinary agencies. The material is local, is too angular to have been transported far, is all derived from the higher ground (though not necessarily from very high ground), is devoid of marine and fluviatile shells, but has occasional mammalian bones and land shells, and does not show regu-

* From the *Independent*.

lar stratification, and occurs outside of the range of glacial ice. In Prof. Prestwich's opinion the efforts to account for this singular and so widely scattered deposit by the wash of the surface debris over the edges of old cliffs, aided by excessive annual rainfall and by floating ice, are unsatisfactory; while the theory of deposit by waves of translation is proved inadequate by the unworn character of the material. The theory that the rubble drift was distributed by the sliding of miniature avalanches of snow and ice over the slopes is also quite improbable, since the slopes are often so slight. Mr. Prestwich, therefore, brings forward the novel theory that this distribution was produced by a series of short and sudden elevations of land which had been temporarily submerged at the close of the glacial period. This submergence he supposes to have extended to a depth of more than a thousand feet, and to have taken place gradually; but the re-emergence was more rapid and by sudden, short impulses, with unknown periods of rest between. Hopkins had shown that in such a depth of water a paroxysmal elevation of from 50 to 100 feet might produce a current of from 5 or 6 to 15 or 20 miles an hour.

"Movements of this character would, like Nasmyth's hammer, be capable at times, when the uplift was rapid, of exerting an enormous force, while at other times, when the uplift was slow, the action might be of the most gentle character."

It should be remarked, however, that Prof. Prestwich had overlooked Darwin's explanation of the phenomena as given in Geikie's "Prehistoric Europe," in which the genius of this great naturalist appears at good advantage. Darwin suggested:

"During the height of the glacial period great beds of frozen snow accumulated over Southern England, and during the summer gravel and stones were washed from the higher land over its surface. . . . Thus alternate layers of frozen snow and drift would ultimately have covered the country to a great thickness. . . . As the climate became warmer the lower beds of frozen snow would have melted with extreme slowness, and . . . the drift would have been deposited almost irrespective of the outline of the underlying land" (p. 141).

The evidence of organic remains found both in this rubble drift and in numerous rock fissures is supposed by Prof. Prestwich strongly to support his theory. The destruction of land animals is known to have been very extensive during that period, and their remains are clustered together as if they had been drowned while taking refuge on the higher lands, upon which the water was very slowly encroaching.

"The evidence of the organic remains is to the same effect, in that they are those of a *land fauna* alone, with an entire absence of marine and fluviatile remains. The bones found in the rubble drift are not only in the same unworn condition as the rock fragments, but they are *free from all marks of gnawing*. This is a proof that the animals had not, as in the caves, fallen a prey to carnivora, but must have met their death in a way which was unusual—such as from drowning; for had their bodies remained on a land surface after death, they would have been subject to being devoured by predaceous animals, or else the bones would have shown traces of weathering and wear. At the same time the *sharply* fractured state, and dispersion of the bones, show that they must have been subjected to considerable violence and displacement. These conditions, as well as the mode of distribution of the rubble from many independent centers, accord in all points with the results that would ensue from the submergence and re-elevation of a land surface from beneath deep waters after a temporary submergence."

It should be said, however, that the evidence of the raised beaches in post-glacial time is not very distinct anywhere in Europe, except on the coast of Norway, and that Sir Archibald Geikie, in the recent edition of his "Geology," and Alfred R. Wallace, in a late discussion of the subject in the *Fortnightly Review*, do not give their adhesion to the theory of an extensive subsidence, either post-glacial or inter-glacial, in Southern England. But the subject is, at the present time, exciting the liveliest interest among British geologists.

Oberlin, O.

TOBACCO.*

By H. B. Cox.

HISTORY.

It has been said that the name tobacco was given to the plant by the Spaniards, because it was first observed by them at Tabasco or Tobaco, a province of Yucatan, in Mexico. Others derive the name from the "tabac," an instrument used by the natives of America in smoking this herb.

The use of tobacco for smoking and chewing purposes is supposed to have been commenced by the North American Indians at a very early period, so early, in fact, that nobody seems to have any idea as to when that period was. It is said that the Spaniards became acquainted with tobacco when they landed in Cuba in 1492, and on their return introduced it into Europe, strongly recommending it for its valuable medicinal properties, about which they probably knew nothing at all.

The custom of inhaling the smoke was learned from the Indians, and by the end of the sixteenth century had become generally known throughout Spain and Portugal, whence it passed into the rest of Europe, and into Turkey, Egypt, and India, although severely opposed and forbidden both by the Christian and Mohammedan governments. Tobacco was introduced into China during the sixteenth century, although its use was strongly prohibited.

It was not till the middle of the sixteenth century that tobacco was seen growing in Europe, first at Lisbon, when the French ambassador, Jean Nicot (hence the name Nicotiana), sent seeds to France in 1560, as those of a valuable medicinal plant, which was, even then, diffused throughout Portugal.

When America was first discovered, and afterward when fresh tracts of the country were explored, the practice of smoking tobacco was found to be prevalent among all the tribes. Tobacco was introduced into Italy in 1560, this being about the same time as its introduction into France. Tobacco was probably first brought into this country in 1565 by Sir John Hawkins, or, at any rate, it seems unlikely that Sir Francis Drake, who is believed to have brought tobacco from Virginia in 1586, was the first to bring it into England.

Perhaps it is safe to assume that Sir Walter Raleigh and his companions were the first in this country to use the herb for smoking purposes; this was in 1584.

One thing, however, is very certain, and that is that the custom of smoking tobacco very quickly succeeded its introduction, and the growth of this habit, in spite of the most strenuous opposition, cannot fail to strike us as remarkable.

SOURCE.

Tobacco is the leaf of *Nicotianum Tabacum* and allied species. The genus *Nicotiana* contains about seventy-three species. Of the various species, *N. Tabacum* is by far the most extensively cultivated. It is a fine plant, growing to a height of six or seven feet. The leaves are sometimes two feet in length, and average about eighteen or twenty inches; they are very shortly stalked, and the base is more or less amplexical; the flower is pink, or pale red. It constitutes a very large proportion of commercial tobacco, being known and cultivated nearly all over the world.

American tobacco is almost exclusively of this species, although many varieties of it are now recognized, such as Kentucky, Big Frederic, Virginia, etc. The same plant furnishes the tobacco of Havana, France, Holland, Belgium, and others. The next important species is *N. Rustica*, or Syrian tobacco. This is a much smaller plant, averaging three and a half feet in height; it has a greenish flower: it furnishes the Turkish, Syrian, and perhaps the Latakia tobaccos. It is a native of America, but is now cultivated chiefly in Asia, Africa, and Europe. It is a hardier plant than *N. Tabacum*.

The third important tobacco is *N. Persica*, which has a white flower. These three species probably constitute the whole of the tobaccos grown, although each has many varieties, especially the first, *N. Tabacum*, which almost invariably forms a fresh variety when it is transplanted.

Until quite recently, "Tumbeki," the Persian tobacco of Eastern commerce, was thought to be the produce of *N. Persica*, some few experts holding the opinion that it was obtained from *N. Rustica*.

This led to much discussion, followed by much conflicting literature, so that seeds of the plant which yielded the tobacco in question were obtained from various reliable people in Persia, and sown at Kew. Meanwhile entire plants were also examined and resembled neither *N. Rustica* nor *N. Persica*, and when the plants grown from the seeds received from Persia were examined they turned out to be those of *N. Tabacum*. This was published in the *Kew Bulletin* for 1891, p. 84.

Not feeling quite convinced on the subject, on account of the various opinions obtained from different sources, I wrote to Kew recently, and a few days ago received the following reply from the director, Mr. W. T. Thiselton Dyer, F.R.S., etc.:

"DEAR SIR: As to Shiraz tobacco, there is no ambiguity as to the conclusion arrived at in the *Kew Bulletin* for 1891, p. 84. What is ordinarily called Turkish tobacco, and as far as I know only used for cigarettes, is the produce of *Nicotiana Rustica*."

This note on the source of Turkish tobacco is in harmony with the statement previously made by me, which I wrote some time ago.

CONSTITUENTS.

The characteristic organic constituent of the tobacco plant is the alkaloid nicotine, with which is generally associated the essential oil or "tobacco camphor," viz., nicotianin. The proportions which all the organic substances in the plant bear to one another greatly affect the aroma and taste of the tobacco. The burning is somewhat influenced by them, but far more by the mineral or inorganic constituents present.

The freshly cut leaves contain over 80 per cent. of water, and the proportion of nicotine varies from 1 to about 10 per cent.

Syrian is one of the lowest; that is, as regards the percentage of nicotine it contains. Two distinct samples that I examined, although widely differing from each other, gave an average of only 0·852 per cent., the actual figures being 1·093 and 0·612

The process of determination was as follows:

Twenty-five grammes (or more or less, according to the amount of the sample at my disposal) of the dried and powdered tobacco was intimately mixed with slaked lime and distilled in a current of steam until the condensed steam was no longer alkaline; the distillate was slightly acidulated with dilute H_2SO_4, and evaporated to a conveniently small bulk. This was made alkaline with soda, and agitated repeatedly with successive portions of ether. The separated batches of ethereal solution of nicotine were then mixed and exposed to the air in a cool place. This exposure to the air carries away ammonia, if any be present, as well as ether.

Water was added to the ethereal residue, and the amount of nicotine present determined by decinormal H_2SO_4, using methyl-orange as an indicator. One c. c. of decinormal H_2SO_4 represents 0·0162 gramme of nicotine ($C_{10}H_{14}N_2$).

It is important that the nicotine should not be left about longer than is absolutely necessary, since it is appreciably volatile at the ordinary temperature.

Sometimes the unconcentrated ethereal solution is titrated, but in such cases ammonia, if present, would make the results high. The neutralized solution is therefore separated from the ether and evaporated to dryness over a water bath and weighed. Some prefer to add a few cubic centimeters of decinormal acid before evaporating, and these would, of course, have to be taken into account.

The residue is treated with absolute alcohol, which dissolves the sulphate of nicotine, but not the ammonium sulphate; the latter must be dried, that is, freed from alcohol and weighed, and this weight, deducted from the weight previously obtained of nicotine sulphate, will leave the absolute weight of nicotine sulphate $(C_{10}H_{14}N_2)_2H_2SO_4$.

Table of Results, Arranged According to Per Cent. of Nicotine.

Variety examined.	Amount of moisture present in sample, per cent.	Total ash, per cent.	"Alkaline salts," *i. e.*, ash sol. in HCl, per cent. of 100 pts. ash.	Nicotine, per cent.
1. Syrian leaves (*a*)	8·70	....	....	0·612
2. American chewing	....	20·6	58·25	0·935
3. Syrian leaves (*b*)	8·00	....	....	1·093
4. Chinese leaves	6·12	....	....	1·302
5. Turkish (coarse cut)	....	....	....	2·500
6. Golden Virginia (whole strips)	14·00	17·82	70·70	2·501
7. Gold Flake (Virginia)	....	18·10	71·00	2·501
8. "Navy cut" (light colored)	....	18·6	....	2·530
9. Light returns (Kentucky)	....	16·1	61·11	2·733
10. "Navy cut" (dark "all tobacco")	....	16·6	....	3·640
11. Best "Bird's-eye"	....	16·0	64·33	3·931
12. Cut Cavendish (*a*)	....	18·62	70·90	4·212
13. "Best Shag" (*a*)	....	15·46	80·25	4·907
14. "Cut Cavendish" (*b*)	....	....	....	4·970
15. "Best Shag" (*b*)	....	....	....	5·000
16. French tobacco	....	17·29	....	8·711
17. Algerian " (*a*)	....	17·29	....	8·813
18. Algerian " (*b*)	....	17·40	....	8·900

The above list includes no proprietary tobaccos, and it must not be inferred that the samples examined were standard samples. They were obtained from very different sources, no two samples of one kind being obtained from the same source. The ash was not determined in Nos. 1, 3, 4 and 5 for want of material, while the examination of Nos. 15, 16, 17, 18 was incomplete for lack of time.

The average percentage of nicotine in Syrian tobacco is from 1 to 2; in Manila and Havana 1 to 3; Virginian and Kentucky up to 7; French up to 9. The French and Algerian samples which I examined resembled each other very closely in every way, which may probably be explained by the fact that much of the Algerian tobacco is imported into France and manufactured at the government factories.

It is supposed that the aroma given off during the smoking of tobacco is due rather to the nicotianin or tobacco camphor than to the nicotine, although the former is present only to a very small amount. The odor given off from an aqueous solution of nicotine, however, was variously described to me as like that of senna tea or a saucepan that cabbage has been boiled in.

The conditions of soil and climate which favor the production of nicotine retard that of nicotianin and *vice versa*. The quantity of nicotine present is no criterion of the quality of the tobacco, inasmuch as many of the most delicately flavored and choice tobaccos contain little of it. The cellulose, gum, etc., in the leaf give off objectionable odors in burning, and fermentation gets rid of or modifies these when present in considerable quantity. The fermentation must not, however, be excessive, or objectionable and injurious ammoniacal salts would be formed. Many tropically grown varieties contain little of these unpleasant constituents, so that in some cases fermentation is dispensed with, and in many others is greatly lessened, sun drying alone often proving sufficient for the preparation of the leaves. The chief organic acids in tobacco are malic, citric, and oxalic, while acetic acid has been found in fermented tobaccos.

The ash of tobacco varies greatly in composition and quality, although the percentage is from 12 to 20; it invariably contains potassium, sodium, calcium, magnesium, aluminum, usually a trace of iron oxide, and carbonic, phosphoric, silicic, and sulphuric acids, and chlorine.

Potash is sometimes present to the extent of 30 per cent. of the total ash, and should be mainly combined with the organic acids. The ready decomposition of the organic potassium salts by heat constitutes a good burning tobacco. The potassium salts are converted into carbonate in burning, and consequently the combined presence of potassium and carbonic anhydride in the ash may be taken as a good indication. From the excess of these two, of course, it follows that the other constituents must be present in smaller proportions, the lime generally lower than the potash, with smaller quantities of magnesia, soda, and alumina. Iron is objectionable, giving a red ash. Lithium is present in the ash of most tobaccos. Silicic and phosphoric acids, even in considerable quantity, do not seem to affect the combustion to any great extent, but chlorine, except in very minute quantity, retards it.

The leaves contain more calcium, magnesium, and silicic acid, and less alkali, phosphoric acid, and chlorine than the stalks. The stalks contain much potassium nitrate, and their presence in "bird's-eye" tobacco renders this tobacco very readily combustible without any addition.

According to Nessler, tobacco burns best when it contains a large proportion of potassium malate, but the effect may be imitated by the addition of acetate or other organic potassium salt. The combustibility may be diminished by the addition of magnesium or calcium sulphate. Sulphates seem to favor proper combination. Mayer observes that tobacco which burns badly can be made to burn well by steeping it for twenty-four hours in a 0·5 per cent. solution of potassium acetate or nitrate. A solution of calcium acetate of the same strength gives excellent results, as I have proved.

Tobacco seeds yield by pressure 30 per cent. of a greenish-yellow, mild, odorless oil, having a sp. gr. of 0·923 at 15° C. This oil quickly dries by exposure to the air.

IMPORTATION.

The forms in which tobacco is imported into this country are many, each variety being purchased according to its suitability for the preparation of some fancy tobacco, and although commercial tobacco is

* Read at a meeting of the School of Pharmacy Students' Association, January 11, 1894.—*Amer. Druggist.*

divided into five classes, every manufacturer has his own method of selection.

The chief imported varieties are Virginian, Kentucky, Maryland, Indiana, Java, China, Japan, Ceylon, Turkish and German. The largest quantities come (1) from the United States of America; (2) Germany; and much less from Japan, India, China, and Eastern countries.

Imported tobaccos generally contain about 14 per cent. of water, although apparently dry and brittle.

MANUFACTURE.

The bulk of imported leaves are used for the manufacture of the fancy tobaccos, the material being chosen according to the variety of salable tobacco required.

Shag is usually made from the darker and stronger varieties.

In "bird's-eye" the prepared leaves are placed in such a manner upon one another that they will be cut right across the mid-rib.

For "twist" or "cake" tobacco the leaves are stripped, moistened, and placed end to end, and then spun into a rope round a reel, or wound into a ball, either by hand, or by a spinning wheel. The whole is then steeped in liquor, and finally oiled with sweet oil. The oiling process greatly affects the ready burning of this tobacco.

In America it is usual to saturate the leaves and stalks previous to pressing into cakes with molasses, or a mixture of this substance and licorice. I have extracted a considerable quantity of glveyrrhizin from this cake tobacco, and have also found ligulate florets in it.

Leaves which are to be made into cigars must possess the following qualities: They must be of good color, possess a fair amount of body, and an agreeable odor, and must give off an agreeable aroma when burning, and last, but by no means least, they must burn well. It should also be mentioned here that a fine texture and small veins are favorable characteristics. A machine is now in use by which mid-ribs and stalks are flattened by pressure, so that they may appear like parts of the lamina.

The "burning test" is to ascertain whether the leaves will continue to burn after being once lighted, although this can be no guide as to the quality of the cigar. Sometimes cigars are made of tobacco which will only burn very slowly and difficultly, in which case it is the rule to mix "fiery" tobacco with them, but this method produces only inferior cigars, and unless they are made with extreme care they do not burn evenly.

The best cigars are made of one kind of leaf only, but in common kinds the interior is a mixture, made up of stalks, etc., concealed in an attractive wrapper. In many foreign cigars the wrapper has been found to contain much potassium nitrate, while the interior, consisting of the same kind of tobacco, contains none. This is added so as to make the wrapper burn down evenly with the interior. Glycerin is said to be sometimes added to keep the cigars from becoming too dry.

Cigars are rarely adulterated, and though not always what their outside would represent them to be, they contain nothing but tobacco. Cases have been reported of cigars containing hay, cabbage, and brown paper, but such cases are extremely rare.

The chief imposition seems to be the practice of placing home-made cigars in imitation foreign boxes. Another custom is to send German and other Continental tobaccos to the West Indies, whence they return as a special brand of West Indian cigars.

Cigars chiefly come from the West Indies (and these, of course, include the German ones), the Philippine Islands, and, recently, from Mexico and Jamaica.

Cigarettes are usually made of light tobacco, such as Turkish, Salonica, etc., which has but little odor, and this a pleasant one. American tobacco is largely used for this purpose.

Snuff is made from finely powdered tobacco stalks. The moisture should not exceed 25 per cent, but is sometimes present to the extent of 50 per cent. It is variously scented. In the United Kingdom nothing is allowed to be added to snuff except the carbonates, chlorides, and sulphates of potassium and sodium, and the carbonate of ammonium.

ENGLISH-GROWN TOBACCO.

From the very first the cultivation of tobacco in England was a success, but this was prohibited by James I. and Charles I., though with little effect. The home grown tobacco was heavily taxed, and it was expected that this would cause the cultivation to be dropped for want of profit. This heavy taxing was due in a great measure to the difficulty experienced in collecting the duty, which was extensively evaded. In 1652 the cultivation in England was prohibited, and shortly afterward an order was issued to destroy the plantations. The illegal growth, however, continued, and the cultivation was not finally stopped until the reign of George III., when, in 1782, an act to this effect was passed, and the tobacco trade was forced out of the country.

Extensive plantations in Yorkshire were by this act destroyed, and the planters heavily fined and imprisoned.

The growth of tobacco in Ireland was not so hampered by opposition, and so it managed to struggle on till 1831, when it was suddenly suppressed.

In 1886, owing to the agricultural depression in this country, the question of cultivating tobacco in England was once more raised. Permission was sought and obtained, with severe restrictions, to make experiments on the subject.

The results were, to say the least of it, promising, although nobody expected we should be able to grow Havana cigars in Kent, even though they do make them in Germany.

In 1887 permission was again obtained, but as soon as the new industry sprang up in this country it encountered tremendous opposition and was finally stopped.

Some samples of English-grown tobacco were analyzed and found to contain, on the average, light leaves 3·6 per cent. and the dark leaves 2·4 per cent. of nicotine. It will be noticed that the proportion of alkaloid in the light leaves was higher than in the dark, the reverse of what is usually the case.

RICE MEAL OR BRAN.

THIS is a material which agriculturists have during recent years been using increasingly and with ample justification, for even now it deserves to be more generally appreciated. Bearing in mind the extremely starchy character of the grain furnishing it, for as it is taken in this country rice is certainly one of the most farinaceous foods, some little surprise may be experienced that a material of the description this proves to be is yielded as a by-product of its preparation for the market, the meal consisting of the removed outer coatings of the seeds, although in many respects wheat bran is similar, and is also, as we know, valuable to the farmer.

It is, however, highly important to procure genuine rice meal when purchasing, as many channels are open for the substitution of an inferior article; thus a material known as rice husks is occasionally met with, which is altogether different in character and feeding value; consequently any one buying a supply consisting partly or entirely of this would suffer to a corresponding extent. Again, there is some considerable risk that sweepings and other warehouse refuse would find an entrance; indeed, from time to time samples are received which, owing to this cause, are totally unfit for use as food; further, there can be no doubt that this material sometimes suffers from admixture with the products of other grain, its physical character rendering it especially adapted to undergo such treatment, thereby affording an admirable and convenient vehicle for the disposal of damaged wheaten flour, etc.

Some of the extraneous matters that might be introduced would exert a positively injurious influence, while others, not in themselves objectionable, must materially diminish the value of the meal by lowering the percentage of oil, and any description of intentional admixture, if the product be sold as genuine, is necessarily fraudulent; clearly, therefore, buyers and *bona fide* sellers need to be on their guard, the one to protect his pocket and the other to prevent his goods falling into disrepute through the action of unscrupulous or careless dealers. Certain varieties of the meal are red and dark in color, and do not meet with a favorable reception; the best qualities have a light shade, being not much browner than oatmeal.

The advantages of rice meal are its high percentage of oil, which averages about 12 per cent., some samples containing as much as 15 per cent. The oil is one that becomes solid at ordinary temperatures, possesses a sweet odor and agreeable taste, and is in every way a satisfactory food constituent; consequently, at about its usual price, £4 per ton, this material provides a cheap source of that principle whose value in feeding stuffs we recently commented upon.

The mild and pleasant flavor of the meal is also an important factor, for obviously it is thus rendered free from any objection as being likely to impart undesirable properties in this respect to dairy produce, while the richness of the ash in phosphoric acid assists in making it well adapted to the preparation of young animals' natural food; therefore numerous and manifest reasons for adopting it as part of the rations of milk cows are apparent, and for this purpose a considerable demand exists, and the proportion of oil being advantageous in the production of cream, while its nature and quality necessarily promote the yield of a well flavored butter.

The chief drawback when using rice meal is the comparatively low percentage of nitrogen it contains, which is equal to about 12 per cent. of albuminous substances; nevertheless, with the exception of only a small proportion, these consist of albuminoids, and they, as nutrients, are by far the most valuable constituents containing this element. However, an increase in the quantity present may be made with advantage, and as the percentage of oil is so considerable, it is possible to mix with materials poor in that ingredient and yet obtain a food supplying a satisfactory amount. For example, by adding beans and peas to rice meal in the proportion of two-thirds of the latter to one-third of the former, a valuable and digestible feeding stuff may be prepared, for these leguminous seeds, although poor in oil, are very rich in nitrogen. Assuming beans to be employed for the purpose, a mixture of the kind would have a composition corresponding approximately with the analysis given below, which at once reveals its value to the farmer. With the object of facilitating comparison, we also give the results obtained from a good sample of rice meal alone:

	Mixture.	Rice Meal.
Moisture	11·68	10·42
Oil	8·82	12·36
Albuminous compounds*	16·31	11·94
Carbonaceous principles	46·79	46·55
Phosphates, etc.	5·83	7·45
Fiber	9·21	9·25
Insoluble matter	1·36	2·05
	100·00	100·00
*Containing nitrogen	2·61	1·91

By exercising reasonable precautions when purchasing, it is evident that in this material agriculturists possess a food which may be made exceedingly useful. —*Bell's Messenger, London, January 29.*

PROFITABLE RICE CULTURE.

WITHIN a few years it has been found practicable to raise rice on the dry lands of Southwestern Louisiana to greater advantage than in the swamps of the Atlantic coast. Of course artificial irrigation is essential, but rice culture in the swamps of the Carolinas is decaying, while in Southwestern Louisiana it is growing rapidly and yielding ample returns. A couple of years ago the crop was excessive, but the last crop is well sold up, and there is little doubt that the consumption of rice will vastly increase in this country. Scientifically and practically it is one of the best foods, and the taste for it is growing. Portions of this section of Louisiana are sufficiently watered by natural overflow, but a good deal of it is scientifically irrigated. Some of the farmers say it is a little more work to cultivate rice than wheat and corn, but most of them think it is less; there is no great difference in the cost. The general testimony is that it costs $5 or $6 an acre to cultivate it, exclusive of irrigation, which, as already said, is not always necessary. A dollar for seed, $2 for cultivation and $2 for harvesting is the estimate of many farmers, though a few put the cost $1 or $2 more and some go as high as $10 or $12. Ten barrels in the rough is regarded by many cultivators as a fair average crop, but yields of twelve and fifteen barrels are common. The farmers generally get from $2 to $3 a barrel and sometimes a little more. A rice cultivator at Lake Arthur, Louisiana, writes: "I can say honestly and positively that a man can make a big fortune in four or five years raising rice. . . . I know a number of farmers that have for the past three years averaged fifteen barrels per acre, and their net average price per barrel for the three years was $2.85." These figures give gross receipts of $42.75 per acre.—*N. Y. Jour. of Com.*

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